DWORSHAK DAM IMPACT ASSESSMENT & FISHERY INVESTIGATION AND TROUT, BASS AND FORAGE SPECIES

Final
Report

U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Idaho Department of
Fish & Game

Nez Perce Department of
Fisheries Management

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DWORSHAK DAM IMPACT ASSESSMENT AND FISHERY INVESTIGATION

AND

TROUT, BASS AND FORAGE SPECIES

Combined Project Completion Report

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Dworshak Reservoir pool recommendations contained herein are independent of conditions for upstream or downstream anadromous fish migration and of any other purposes not specifically stated. Nothing in this report shall limit or restrict future water rights claims or flow recommendations made by the Nez Perce Tribe for any purposes. The authors also recognize that the needs of the resident fish studied may conflict with the needs of downstream anadromous fish. This report makes no attempt to resolve the conflicts or recommend priorities among alternative uses of Dworshak Reservoir water.

EXECUTIVE SUMMARY

The Nez Perce Tribe (NPT) and the Idaho Department of Fish and Game (IDFG) entered into separate intergovernmental agreements with the Bonneville Power Administration in a cooperative, four-year effort to study impacts of Dworshak Dam operation on resident fisheries. The NPT Department of Fisheries Management focused on rainbow trout, smallmouth bass and forage fish. The IDFG's segment of the project was to document kokanee population dynamics, relate it to the changing nutrient status of the reservoir, evaluate kokanee losses through Dworshak Dam, and make kokanee management recommendations. This final report includes findings for 1990 and 1991 and relates these data to information previously presented in annual reports for 1987, 1988 and 1989.

Both early and late spawning kokanee were introduced to the reservoir as early as 1972. Late spawning kokanee which are primarily shore spawners are gone, likely due to water level fluctuations during spawning seasons. Early spawning kokanee, which are primarily tributary spawners, developed a self-sustaining population and support about 80% of the fishing pressure on the reservoir. The kokanee fishery declined during our study from a harvest of 206,000 kokanee and a catch rate of 1.5 fish/hour in 1988 to 95,000 kokanee at a catch rate of 0.8 fish/hour in 1990. Limited surveys in 1991 indicated a further decline in catch rates to 0.5 fish/hour. Changes in the kokanee fishery reflected population changes in the reservoir. Mid-water trawling in 1989 indicated the reservoir contained 13 kokanee of harvestable size per acre but that dropped to 2 kokanee per acre in 1991. Angler satisfaction also declined throughout the study from 37% rating the fishing as poor in 1988, to 55% giving it this rating in 1990. Nearly all anglers cited low numbers of fish caught as the reason for the rating. Management goals should therefore be towards more numerous but slightly smaller kokanee to maximize angler satisfaction.

Dworshak kokanee have exceedingly low annual survival rates; much lower than other kokanee populations. Over 80% of yearling kokanee die before recruiting to the fishery the following year. Losses of kokanee through Dworshak Dam appear responsible for the high mortality rates. As many as 83,000 to 235,000 kokanee of a single age group were estimated to be lost annually. The resulting low densities reduced catch rates from 1.5 to 0.5 fish/hour and likely reduced fishing effort by 66%. Low kokanee density has, however, triggered good growth rates. Kokanee averaged 11 inches by July of their third summer in the reservoir. This compares to 7.5 inches in Coeur d'Alene Lake, and 8.3 inches in Lake Pend Oreille. Kokanee in these other lakes live to be 1 to 3 years older than Dworshak Reservoir kokanee and so ultimately make up some of the difference in length.

During our study, Dworshak Reservoir was much more nutrient poor than when it was first filled in 1971. We would have expected nutrient input from inundated vegetation and soils to have stabilized, however, our results indicated the reservoir may still be declining in nutrient status.

Near-shore habitat has also been altered since initial inundation. Vegetation along the shoreline has been eliminated due to fluctuating water levels and wave action. Cover and food production for littoral fish species have been adversely affected by this change. Abundance of redside shiners, an important forage species, peaked only a few years following initial impoundment. This species was in decline prior to the reservoir-wide expansion of smallmouth bass. Collapse of the redside shiner population was likely induced by reduced reservoir productivity and deterioration of near-shore habitat. Bedside shiners are now virtually

absent in Dworshak Reservoir. In response, the diet of smallmouth bass has changed from redside shiners and crayfish during the early reservoir years to a more diverse diet of several fish species, aquatic invertebrates and terrestrial invertebrates.

Anglers fished an estimated 149,592 hours during 1990 to catch 94,757 kokanee, 19,673 smallmouth bass, 12,981 rainbow trout, 157 cutthroat trout and 151 bull trout. Other fish caught, including whitefish, black crappie, brown bullhead, northern squawfish and suckers, totalled 282. The overall catch rate was .86 fish/hour.

During 1991, creel surveys were limited to January and February. Boat anglers fished 31 hours during January to catch 8 rainbow trout at .26 fish/hour. Bank anglers caught 230 rainbow trout during 320 hours of fishing for a catch rate of .72 fish/hour. February boat anglers fished 697 hours to catch 67 rainbow trout and 16 kokanee, for a combined catch rate of .12 fish/hour. Bank anglers fished 584 hours during February to catch 210 rainbow trout at .36 fish/hour.

Harvest of kokanee has increased since the early 1970's, and the rainbow trout harvest has declined. Although the species composition of the catch has changed, overall catch, effort and catch rates are currently similar to the early 1970's fishery.

Smallmouth bass harvest averaged less than 1,000 fish from 1988 though 1990. Only 1 out of 10 bass caught were kept. Modeling indicated that reducing the minimum size limit from 12 inches to 10 inches could increase harvest number and harvest weight by 77% and 24%, respectively. Minimal impact on age 5 and older bass would be anticipated. The relative plumpness of smallmouth bass from 4 inches to 12 inches suggests that this is the size range that experiences the most competition for food. A 10-inch minimum size limit would allow harvest of fish within a portion of this size range. The increased harvest could ease food competition and improve body condition.

Smallmouth bass can successfully reproduce with reservoir pool conditions as observed from 1987 through 1990. Rising pool levels during June may cause temperatures to decline at nesting locations, resulting in unsuccessful initial spawning attempts. Stable pool levels during the summer recreation period afford suitable conditions for successive attempts at spawning and fry rearing from July through August. Downward fluctuations in pool level from June through August could result in reproductive failure, especially if the pool level is not stabilized for a minimum period of one month. The smallmouth bass is currently the most abundant self-sustaining game fish inhabiting the shallow water areas of Dworshak Reservoir.

An average of 21,890 pounds of rainbow trout were stocked annually 1988 through 1990. The number of rainbow trout stocked averaged about 250,000. Although substantially less than the 100,000 pounds identified for resident fish mitigation, the recent stocking levels have supported monthly catch rates of 1 fish/hour or better during the target fall-winter rainbow trout fishery.

Recently stocked rainbow trout caught by boat anglers targeting on kokanee are typically released. The boat angling catch rate for rainbow trout stocked in May 1990 at 5 inches total length was less than one-half the catch rates observed for 1988 and 1989, when trout were stocked in June at 6 1/4 inches. An improved catch rate during the 1990 target fall-winter bank fishery for rainbow trout followed the reduced incidental catch by boat anglers. No rainbow trout were available for stocking during 1991 due to disease.

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INTRODUCTION

The Northwest Power Planning Council's Columbia River Basin Fish and Wildlife Program [903(e)(4)] authorized the Bonneville Power Administration to fund a four-year study to assess the impacts of Dworshak Dam operation on reservoir fisheries. Research was conducted from 1987 through 1991 as a cooperative effort among the Idaho Department of Fish and Game (IDFG) and the Nez Perce Tribe of Idaho (NPT). IDFG evaluated kokanee Oncorhynchus nerka population dynamics and documented changes in reservoir productivity. The NPT Department of Fisheries Management investigated the status of smallmouth bass Micropterus dolomieui, rainbow trout O. mykiss and their fisheries.

In 1971 the gates on Dworshak Dam were closed and initial filling began. This event converted 86 km of the North Fork Clearwater River from an anadromous fish spawning and rearing river to a fluctuating reservoir environment. Chinook salmon O. tsawytscha and steelhead O. mykiss were lost from the drainage because no fish ladders were constructed at the 219 m high dam. Important reservoir fisheries for kokanee, smallmouth bass and stocked rainbow trout soon developed. Early reservoir data (Pettit et al. 1975)(Ball and Pettit 1974) indicated an abundant population of redside shiners Richardsonius balteatus, an important forage fish for trout and bass. Later information by Horton (1981) indicated a large decline in redside shiners, but a large increase in the abundance of kokanee. Falter et al. (1979) examined Dworshak Reservoir soon after initial impoundment and found it to be moderately productive. Later data (Falter 1982) showed decreased reservoir productivity and lower nutrient levels. Prior to our study, the last comprehensive analysis of the reservoir environment and its fisheries was in the early 1980's. Our intent was to develop new fishery management direction based on current reservoir conditions.

OBJECTIVES

1. To assess the status of kokanee stocks, particularly with respect to age, growth, recruitment, escapement, abundance and mortality rates (fishing and natural).

2. To document losses of kokanee through the turbines at Dworshak Dam and relate to various discharge and reservoir levels.

3. To assess basic limnological parameters of Dworshak Reservoir and relate to fish production.

4. To evaluate size and species composition, relative abundance and distribution of zooplankton in Dworshak Reservoir.

5. To evaluate the impacts of reservoir management on primary productivity, the zooplankton community and the kokanee population.

6. To assess the status of rainbow trout, smallmouth bass and forage species, particularly redside shiners.

7. To assess changes in populations of rainbow trout, smallmouth bass and forage species in relation to reservoir management.

8. To recommend measures to protect, mitigate and enhance resident fisheries in Dworshak Reservoir.

DESCRIPTION OF STUDY AREA

Dworshak Dam is located on the North Fork of the Clearwater River 3.2 km upstream from its confluence with the mainstem (Figure 1). The dam is about 5.2 km northeast of Orofino in Clearwater County, Idaho. At 219 m high it is the largest straight-axis concrete dam in the United States. Three turbines within the dam have a total operating capacity of 450 megawatts. Water can be discharge from the reservoir through the turbines, outlet gates, or tainter gates on the spillway.

Dworshak Reservoir is 86.2 km long and has 295 km of mostly steep shoreline. Maximum depth is 194 m with a corresponding volume of 4.28 billion m^3 at full pool. Surface area when full is 6,644 hectares and mean depth is 56 m. It contains 5,396 hectares of kokanee habitat (defined as area over 15.2 m deep). Mean annual outflow is 162 m^3/s. The reservoir has a mean retention time of 10.2 months. Retention time is variable depending on precipitation and has ranged from 22 months in 1973 to 6 months during 1974 (Falter 1982). Drawdowns of 47 m reduce surface area as much as 52% (3,663 ha). Dworshak Reservoir initially reached full pool on July 3, 1973.

Reservoir Operation

The primary purposes of Dworshak Dam are flood control and power production. Dam operation is integrated with the total system of Columbia River reservoirs to meet power system load requirements and to provide flood control regulation on the lower Columbia, lower Snake, and lower Clearwater Rivers. Power production is highest during the fall, winter, and early spring.

Reservoir evacuation is scheduled to commence on September 1, in accordance with the U.S. Army Corps of Engineers' operating curve for flood control, and continues through March (Figure 2). Recent operation has resulted in drawdowns from September through December in excess of that required for winter flood control. Refilling occurs with the influx of spring flows from April to July. The date of filling to normal full pool varies from mid-June to late July, depending on run-off conditions. Dworshak failed to refill to normal full pool during 1988.

The normal operating range of Dworshak Reservoir is from 440.5 m to 487.8 m above mean sea level. Annual pool level fluctuations up to 47 m reduce surface area as much as 52% (3,663 ha).

Fish Species and Abundance

Prior to impoundment, fish species present in the study area included steelhead trout, chinook salmon, cutthroat trout (O. clarki), bull trout (Salvelinus confluentus), brook trout (S. fontinalis), mountain whitefish (Prosopium williamsoni), brown bullhead (Ictalurus nebulosus), smallmouth bass, chiselmouth (Acrocheilus alutaceus), northern squawfish (Ptychocheilus oregonensis), bridgelip sucker (Catostomus columbianus), largescale sucker (C. macrocheilus), speckled dace (Rhinichthys osculus), longnose dace (R. cataractae), redside shiner, and Pacific lamprey (Entosphenus tridentatus).

Following impoundment, a Memorandum of Understanding between the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service designated that 45,360 kg of resident fish be stocked annually to mitigate dam induced losses. A stocking program of various species, including cutthroat trout, bull trout, rainbow trout, smallmouth bass, and kokanee, followed (Miller 1987)(Table 1).

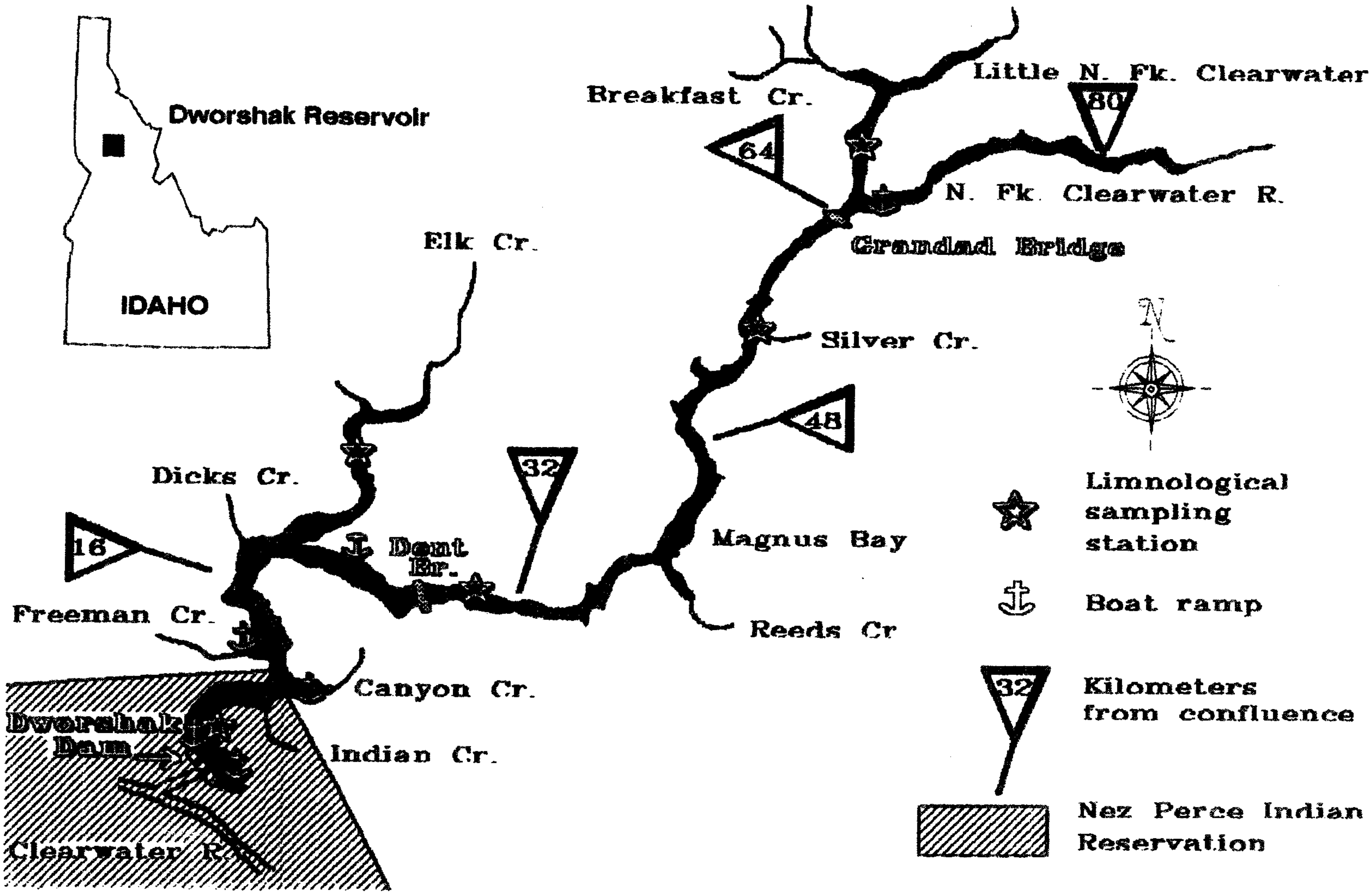


Figure 1. Dworshak Reservoir and major tributaries, North Fork Clearwater River, Idaho. The reservoir was divided into three sections for sampling: Section 1 (dam to Dent Bridge), Section 2 (Dent Bridge to Grandad Bridge), and Section 3 (Grandad Bridge to end of pool).

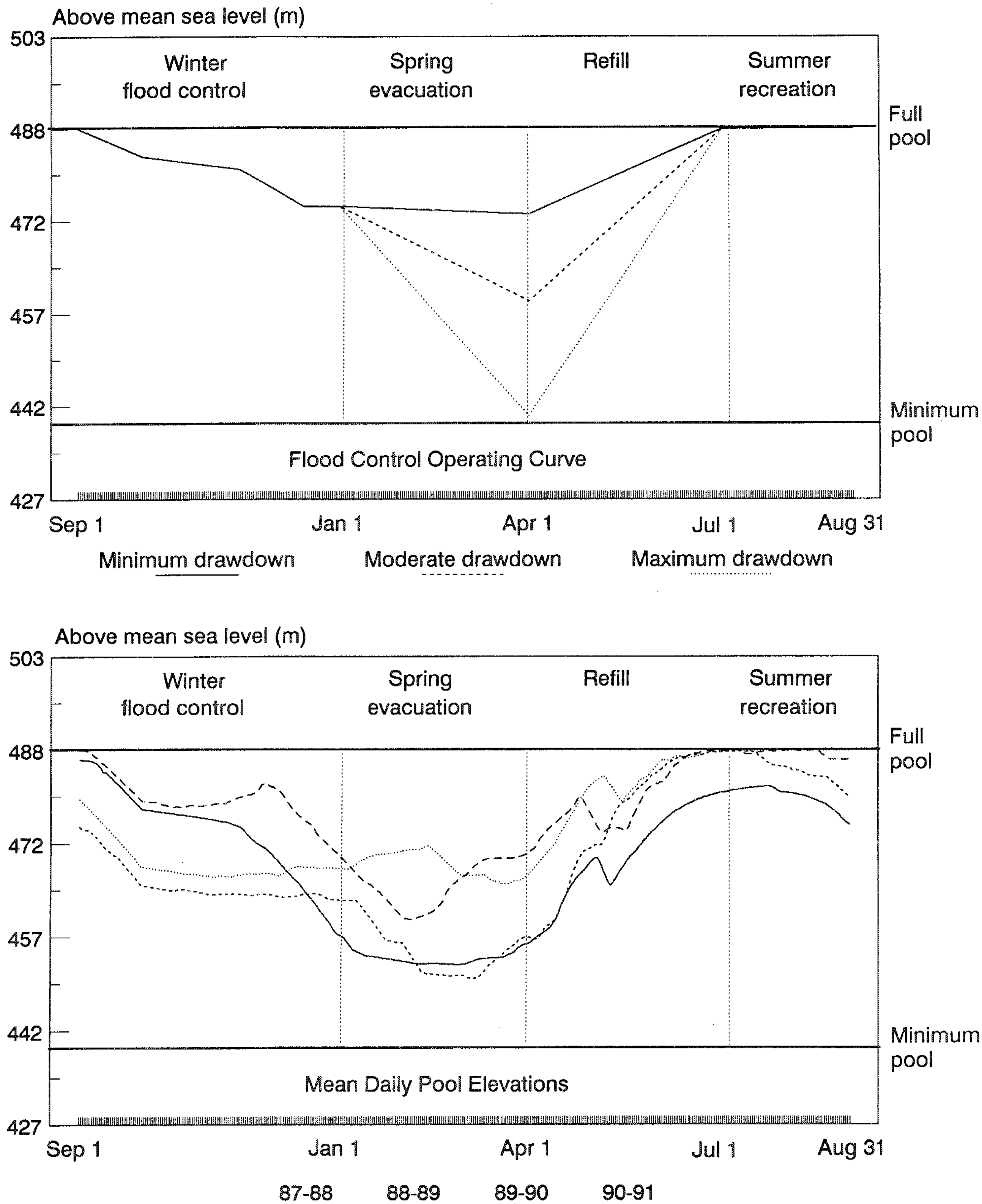


Figure 2. U. S. Army Corps of Engineers' flood control operating curve and mean daily pool elevations for the 1987-88, 1988-89, 1989-90 and 1990-91 flood control cycles, Dworshak Reservoir, Idaho.

Table 1. Fish stocking into Dworshak Reservoir by year, 1972 through 1991.

Year	Species (size class)[1]	Number		Weight kg	Weight lbs	Fish/lb	Length[2] (mm)
1972	Rainbow trout						
	catchables	269826		---	---	---	---
	fingerlings	268060		---	---	---	---
	fry	505570		---	---	---	---
	Rbt total		1043456	45373	99941		
	Kokanee (fingerlings)		1012745	4620	10176	99.5	82
	Total		2056201	49993	110117		
1973	Rainbow trout						
	catchables	228526		53870	118657	1.9	279
	fingerlings (large)	237900		2962	6524	36.5	104
	fingerlings (small)	2086552		3077	6778	307.8	51
	Rbt total		2552978	59909	131959		
	Steelhead (adult)		834	--	--	---	---
	Kokanee (fingerlings)		591192	178	393	1504.3	33
	Smallmouth bass (fry)		50000	1	3	---	<25
	Total		3195004	60089	132355		
1974	Rainbow trout						
	catchables	16702		1715	3777	4.4	210
	fingerlings	750228		3375	7434	100.9	74
	Rbt total		766930	5090	11211		
	Steelhead (adult)		653	--	--	---	---
	Cutthroat trout (fingerlings)		45463	1037	2285	19.9	133
	Kokanee (fingerlings)		217300	908	1999	108.7	80
	Smallmouth bass (fingerlings)		105000	271	596	176.2	59
	Total		1135346	7305	16091		
1975	Rainbow trout						
	catchables	234695		48627	107107	2.2	264
	fingerlings (large)	95520		1162	2560	37.3	103
	fingerlings (small)	557506		240	529	1053.9	34
	Rbt total		887721	57094	110196		
	Cutthroat trout (fingerlings)		111010	362	797	139.3	70
	Bull trout (subcatchables)		122789	4843	10667	11.5	153
	Kokanee						
	early spawners (fingerlings)	74120		198	436	170	68
	late spawners (fingerlings)	3010753		1564	3446	873.7	40
	Kokanee total		3084873	1762	3882		
	Smallmouth bass (fingerlings)		100253	45	100	1002.5	33
	Total	4306646	64107	125642			

[1] Size classes are defined as per Leitritz and Lewis (1980), as follows:

Size class	Criteria
fry	< 25.4mm (1 inch)
fingerling	≥ 16 fish per pound
subcatchable	< 16 and >6 fish per pound
catchable	≤ 6 fish per pound.

[2] Lengths were derived from length-weight tables in Piper et. al.(1982).

Table 1 (continued). Fish stocking into Dworshak Reservoir by year, 1972 through 1991.

Year	Species (size class)[1]	Number		Weight kg	Weight lbs	Fish/lb	Length[2] (mm)
1976	Rainbow trout						
	catchables	97707		17982	39609	205	254
	fingerlings	615000		974	2146	286.6	52
	Rbt total		712707	18956	41755		
	Kokanee-late (fingerlings)		1326000	291	640	2071.9	30
	Smallmouth bass (fry)		50000	1	3	---	<25
	Total		2088707	19248	42398		
1977	Rainbow trout (various)		1162670	15535	34217	---	---
	Kokanee (fingerlings)		2450000	505	1113	2201.3	29
	Smallmouth bass (fry)		50000	7	15	3333.3	<25
	Total		3662670	16047	35345	---	---
1978	Rainbow trout (various)		25936	6090	13414	---	---
1979	Rainbow trout						
	catchables	313088		35586	78384	4	217
	subcatchables	106906		4159	9161	11.7	152
	fingerlings	893530		2261	4981	179.4	61
	Rbt total		1313524	42007	92526		
	Kokanee (fingerlings)		1117464	447	985	1134.5	36
	Smallmouth bass (fry)		100000	9	20	5000	<25
	Total		2530988	42463	93531		
1980	Rainbow trout						
	catchables	75013		11478	25281	3	239
	fingerlings (large)	37200		1056	2325	16	137
	fingerlings (small)	1504232		3836	8449	178	61
	Rbt total		1616445	16370	36055		
	Total		1616445	16370	36055		
1981	Rainbow trout (various)		861429	39520	87049	---	---
1982	Rainbow trout (various)		153956	15863	34940	---	---
1983	Rainbow trout (various)		574255	26560	58503	---	---
1984	Rainbow trout (various)		67561	12387	27285	---	---
1985	Rainbow trout (catchables)		120000	18160	40000	3	239
1986	Rainbow trout						
	Shasta (subcatchables)		156773	6532	14388	10.9	156

[1] Size classes are defined as per Leitritz and Lewis (1980), as follows:

Size class	Criteria
fry	< 25.4mm (1 inch)
fingerling	≥ 16 fish per pound
subcatchable	< 16 and >6 fish per pound
catchable	≤ 6 fish per pound.

[2] Lengths were derived from length-weight tables in Piper et al.(1982).

Table 1 (continued). Fish stocking into Dworshak Reservoir by year, 1972 through 1991.

Year	Species (size class)[1]	Number		Weight kg	Weight lbs	Fish/lb	Length[2] (mm)
1987	Rainbow trout						
	Kamloop (fingerlings)	93856		1705	3755	25	118
	Other (fingerlings)	80400		608	1340	132.2	68
	Total		174256	2313	5095		
1988	Rainbow trout						
	Arlee (subcatchables)	140910		5993	13200	10.7	157
	Shasta (subcatchables)	153998		6774	14920	10.3	158
	Total		294908	12766	28120		
1989	Rainbow trout						
	Arlee (subcatchables)	116271		5121	11280	10.3	158
	Shasta (subcatchables)	129109		5412	11920	10.8	156
	Total		245380	10533	23200		
1990	Rainbow trout						
	Arlee (subcatchables)	113817		3360	7400	15.4	138
	Shasta (subcatchables)	108209		3155	6950	15.6	138
	Total		222026	6515	14350		
1991	None		0	0	0	---	---

[1] Size classes are defined as per Leitritz and Lewis (1980), as follows:

Size class	Criteria
fry	< 25.4mm (1 inch)
fingerling	≥ 16 fish per pound
subcatchable	< 16 and >6 fish per pound
catchable	≤ 6 fish per pound.

[2] Lengths were derived from length-weight tables in Piper et al. (1982).

Horton (1981) reported that largemouth bass (<u>Micropterus salmoides</u>) entered the creel as early as 1976, apparently from contaminated smallmouth bass stocking. Horton (1981) also confirmed the presence of northern pike (<u>Esox lucius</u>), but indicated a low probability of a viable population becoming established. A lamprey ammocete was also collected by Horton while electrofishing near river km 80. Lamprey were also collected annually by IDFG from 1988 through 1992 while trawling for kokanee. Lamprey parasitism on sport fish in Dworshak Reservoir has been reported by Ball and Pettit (1974), Pettit (1976), and Wallace and Ball (1978). Twenty-one fish species are currently known to inhabit Dworshak Reservoir (Table 2).

The reservoir supports a regionally important fishery and is approximately 1.5 hours by road travel from the population centers of Lewiston, Idaho and Clarkston, Washington. Kokanee is currently the most sought after species and are known for their large size in comparison to other Idaho waters. The Idaho state record smallmouth bass, weighing 3.3 kg, was taken from Dworshak Reservoir in 1982.

Limnology and Habitat

Falter et al. (1979) characterized Dworshak Reservoir as a deep, coldwater reservoir with the downstream 32.2 km being monomictic and the remaining upstream portion being dimictic. Falter's work showed that, after three years, the reservoir dropped from moderately productive to oligotrophic. Wave action on exposed side and bottom sediments was identified as a continuous source of turbidity. Phosphorus was noted as the nutrient generally limiting algal growth.

Tributary feeder streams influence reservoir habitat in the immediate inflow areas as well as in the major arms. Pettit (1976) stated that, because of the inflow of organisms in the vicinity of stream mouths, fish have a tendency to concentrate in these areas. Falter et al. (1979) found water quality in Elk Creek Arm to be more similar to Elk Creek than the North Fork Clearwater River. During the 1977 low run-off year, Falter (1982) recorded a sharp early summer temperature increase in Elk Creek Arm, probably as a result of warm Elk Creek inflows.

Floating log rafts at specified log dump locations, such as Merry's Bay, Canyon Creek, and Little North Fork River, locally influence habitat parameters including water quality and cover. In situ bioassays by Falter et al. (1979) showed that log leachates generally increased algal production. A toxic response was noted in some algal genera. Pettit (1976) noted that invertebrates found in fish stomachs were associated with floating debris.

Fluctuations in water level, coupled with unstable steep-sided banks, essentially preclude volunteer establishment of rooted littoral vegetation. Rooted herbaceous vegetation does occur on some gentler slopes, however these areas are above the waterline during the reservoir evacuation period. Analysis of fish stomach contents by Pettit (1976) and Statler (1989) indicated that terrestrial insects, especially of the order Hymenoptera, constitute a major source of food for reservoir fish.

Table 2. Fish species inhabiting Dworshak Reservoir, Idaho (modified from Horton 1981).

Common Name	Scientific Name
Chiselmouth	*Acrocheilus alutaceus*
Bridgelip sucker	*Catostomus columbianus*
Largescale sucker	*Catostomus macrocheilus*
Sculpin	*Cottus* spp.
Northern pike	*Esox lucius*
Pacific lamprey	*Entosphenus tridentatus*
Brown bullhead	*Ictalurus nebulosus*
Pumpkinseed[1]	*Lepomis gibbosus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
Kokanee	*Oncorhynchus nerka*
Black crappie[2]	*Pomoxis nigromaculatus*
Mountain whitefish	*Prosopium williamsoni*
Northern squawfish	*Ptychocheilus oregonensis*
Longnose dace	*Rhinichthys cataractae*
Speckled dace	*Rhinichthys osculus*
Redside shiner	*Richardsonius balteatus*
Cutthroat trout	*Oncorhynchus clarki*
Rainbow trout	*Oncorhynchus mykiss*
Bull trout	*Salvelinus confluentus*
Brook trout	*Salvelinus fontinalis*

[1] Occurrence of *Lepomus* sp. was confirmed by Statler (1990).

[2] Occurrence of *Pomoxis nigromaculatis* was confirmed by Statler (1989).

METHODS

Kokanee

Abundance

Oblique tows of a midwater trawl were used to obtain density estimates of kokanee and representative samples of fish for aging. An 8.5 m, 140 horsepower diesel engine boat towed the trawl net which was 13.7 m long with a 3 m by 3 m mouth. Mesh sizes (stretch measure) graduated from 32 mm to 25 mm to 19 mm to 13 mm in the body of the net and terminated in a 6 mm mesh cod end.

All trawling was conducted after dark during the new moon phase to optimize capture efficiency (Bowler et al. 1979). Net towing speed was 1.1 m/s during 1988, 1.3 m/s during 1989, and standardized at 1.5 m/s during 1990 and 1991. Depth of the net was determined for each 15.2 m distance of tow cable and checked annually. The layer of kokanee distribution was determined using a Raytheon Model 78841 depth sounder with a 20 degree transducer. This vertical distribution of kokanee was divided into 3.5 m sublayers; usually 3 to 5 sublayers encompassed the vertical distribution. A step-wise oblique net tow was made through the kokanee layer. Net was pulled for 3 min in each sublayer, sampling 2,832 m^3 of water over a distance of 315 m (at a boat speed of 1.5 m/s). The time it took to readjust the net between sublayers and the time the net was in the kokanee layer while initially setting the net was also entered into density estimates (approximately 30 seconds between sublayers while raising and lowering the net).

A stratified random sampling design was used to choose trawl locations. The reservoir was divided into three sections with Dent bridge and Grandad bridge serving as boundary lines (Figure 1). Section 1 was the lower end of the reservoir (2,959 hectares of kokanee habitat), section 2 the middle (1796 hectares of kokanee habitat), and section 3 was the upper reservoir (641 hectares of kokanee habitat). Five to seven trawls were made in each section. Reservoir sections were the same each year but trawl locations were randomized annually. Trawl direction was parallel to the long axis of the reservoir due to spacial limitations.

Trawls were conducted on July 11 to 13, 1988, June 5 to 7, 1989, June 27 to 30 1989, September 25 to 28, 1989, September 17 to 20, 1990, and July 8 to 12, 1991.

The number of kokanee of a specific age class collected in each haul was divided by the volume of water sampled to obtain age specific density estimate. These densities were then multiplied by the thickness of the kokanee layer (in m) at the trawling site and then multiplied by 10,000 to obtain the number of kokanee per hectare at that site. Mean densities in each section were multiplied by the area of that lake section to obtain population estimates and summed to make whole-lake population estimates. Parametric statistics were then applied to the density estimates to calculate 90% confidence limits. Mean kokanee weights in each 10 mm size group were averaged to determine the mean weight of kokanee in an age class, and multiplied by the population estimate of that age class to determine biomass.

Age, Growth, and Maturity

Kokanee scales were removed from trawl-caught fish and impressed in clear plastic laminate sheeting using a Carver Model C laboratory press. We exerted 6 metric tons of force for approximately 10 s in making the impressions. Plastic impressions were then read on a microfiche reader by two individuals to resolve discrepancies.

Spawning Trends

Visual counts of kokanee spawners were made by walking upstream in selected tributaries of Dworshak Reservoir during the peak of the fall spawning run to obtain a relative index of kokanee spawner abundance. Streams surveyed included Isabella, Skull, Quartz, Dog, Beaver, Elk, and Breakfast Creeks. Surveys ran from the creek mouth upstream to the end of spawning run or to a migration barrier. Surveys were conducted as close to September 25 as possible to enumerate early spawning kokanee and in mid-November of 1987 to determine if late spawning kokanee were present.

Entrainment

Snorkeling was conducted below Dworshak Dam between February 1990 and May 1991 to count both live and dead kokanee and establish trend information. One or two snorkelers drifted down the North Fork of the Clearwater River approximately 2 m from the bank counting kokanee and estimating age class. On the west side of the river, snorkeling was conducted from the fish collection facility immediately below the dam to the public boat launch (a total of 2.5 km). On the east side of the river snorkeling was conducted from the rock outcropping 100 m below the dam to the railroad bridge (a total of 2.5 km).

Data on discharge from Dworshak Dam, reservoir elevation, depth of water withdrawal, and date, were regressed against the kokanee counts to determine if trends occurred.

TROUT, BASS AND FORAGE SPECIES

Abundance

Variable mesh horizontal gill nets were used to determine relative abundance and species composition. Nets used were 1.8 m by 45.8 m and consisted of six equal panels of 13, 19, 25, 38, 51, and 63 mm bar mesh monofilament. Net design was equivalent to that used by Ball and Cannon (1973) except for the addition of the 13 mm bar mesh panel.

Gill net sample sites approximated locations used by Pettit (1976) and Horton (1981). One floating and one sinking net were fished per sample set. Nets were set at dusk and retrieved the following morning. The date and time of net set and retrieval were recorded for determination of fish per net-hour catch rates.

Gill net data reported by Pettit (1976, 1977) and Horton (1981) were used as bases for comparison. A core sampling period of June through September was used for historical comparisons to reduce seasonal sampling bias.

Growth

Length and weight data were obtained from anglers, gill netting, electro-fishing and hook-and-line sampling. Data collection for growth comparisons of Shasta and Arlee strain hatchery rainbow trout was initiated in the late spring of 1988. The 1988 Shasta and Arlee strain release groups were marked with left pelvic (lv) and right pelvic (rv) fin clips, respectively. The 1989 Shasta and Arlee strain release groups were marked with left pelvic and adipose (lvad) and right pelvic and adipose (rvad) fin clips, respectively.

All stocked rainbow trout were reared at Hagerman National Fish Hatchery, Hagerman, Idaho. Hatchery rearing was conducted to minimize differences between strains at time of release. Mean sizes of Shasta and Arlee strain rainbow trout released in 1988 were 158 and 157 mm, respectively. Mean sizes of the Shasta and Arlee strains released in 1989 were 156 mm and 158 mm, respectively (Appendix A). Pre-release health evaluations were conducted by the Dworshak Fish Health Laboratory for both strains and no differences in fish health were detected for either release year.

Project personnel were present during fish stocking to direct balanced releases at individual release sites (Appendix A). Fish were released from fish transportation trucks ferried to specific release sites by a U.S. Army Corps of Engineers (USACE) barge.

Acetate impressions of smallmouth bass scales were made from readable scales and were magnified (24X) for reading on a microfiche projector. Distances in mm from the focus to the outer edge of the scale (radius) and from the focus to the outer edge of each annulus were measured. The y-intercept of the body-scale regression was used for back-calculation of length at age, L_i, following the Lee formula as described by Carlander (1981):

$$L_i = a + \frac{L_c - a}{S_c} S_i$$

Where a = y-intercept of the body-scale regression

L_c = length of the fish at capture

S_c = scale measurement to the edge of the scale

S_i = scale measurement to each annulus.

Mean length at age was obtained from back-calculated lengths derived from 1988 and 1989 scale samples. These data were used to fit the von Bertalanffy growth equation:

$$l_t = L_\infty \left(1 - e^{-K(t-t_0)}\right)$$

Where l_t = length at age t

L_∞ = ultimate length

K = growth coefficient

t = age t

t_0 = time when length would be 0.

Per Everhart and Young (1981), a Walford plot of mean length at age n versus length at age n+1 was used to derive estimates of L_∞ and K. Linear regression of the natural logarithm of $L_\infty - L_t$ versus age t was used to determine t_0.

The resulting von Bertalanffy growth curves for 1988 and 1989 were compared to a growth curve derived from 1980 smallmouth bass data (Horton 1981) from Dworshak Reservoir.

Food Habits

Stomach samples were collected from gill netting, electro-fishing, hook-and-line sampling and fish brought to the creel. Preserved stomach contents were labeled and sent to the University of Idaho aquatic entomology laboratory for identification, enumeration and volumetric analysis.

Hynes (1950), Usinger (1971) and Bowen (1983) cited limitations in the various approaches to quantitatively describe diet. To provide a diverse reference for diet analysis, fish stomach contents were analyzed by percent by volume, percent by number, frequency of occurrence, and the Coefficient of Importance (C.I.) as used by Ersbak and Haase (1983).

Smallmouth Bass Mortality

The total instantaneous mortality rate (Z) was estimated using a catch curve as described by Ricker (1975). The $\log_e$ of the sample (y-axis) was plotted against age (x-axis), and the slope of the descending limb of the plot, with sign changed, approximated Z. The rate of exploitation from fishing (*u*) was estimated from angler tag recovery during the 1989 fishing season. Floy tags indicating a $5.00 reward for tag returns were inserted near the posterior base of the dorsal spiny rays on legal size smallmouth bass (≥305 mm). Additional indices relative to smallmouth bass mortality were calculated as follows:

Survival rate	$S = e^{-Z}$
Total actual mortality	$A = 1 - S$
Instantaneous fishing mortality	$F = (Z / A)\, u$
Instantaneous natural mortality	$M = Z - F.$

Smallmouth Bass Length-Weight Indices

Proportional Stock Density - Proportional stock density (PSD) (Anderson and Weithman 1978) was calculated for smallmouth bass collected by electro-fishing and gill netting during 1989. PSD for smallmouth bass is defined as follows:

$$\frac{\text{Number of fish} \geq 280 \text{ mm}}{\text{Number of fish} \geq 180 \text{ mm}} \times 100 = \text{PSD}$$

Smallmouth bass ≥180 mm are considered to be stock size and those ≥280 mm are quality size. Anderson and Weithman (1978) suggested that smallmouth bass populations with PSD near or within a range of 30-60 exhibit a favorable or balanced stock structure.

Relative Weight - Mean relative weight (W_r) indices were calculated for four size groups (≤100 mm, 101-200 mm, 201-300 mm, and >300 mm) of smallmouth bass from Dworshak Reservoir, with W_r defined as:

$$(W / W_s) \times 100 = W_r$$

Where W = individual weight of fish

W_s = length and species specific standard weight.

The length-weight equation identified by Anderson (1980) for calculation of length specific standard weights for smallmouth bass is:

$$\log W_s = -4.983 + 3.055 \log L$$

Where W_s = standard weight (gm)

L = total length (mm).

As suggested by Murphy et al. (1991), an overall mean W_r value was not calculated due to the risk of masking length-related trends in fish condition. A mean W_r of 100 for a broad range of size groups within a population may reflect generally efficient utilization of available food resources. When mean W_r values fall well below 100 for a size group, problems exist in food and feeding relationships. W_r values well above 100 for a size group may indicate that fish within the population may not be making the best use of available prey (Anderson and Gutreuter 1983).

Smallmouth bass Equilibrium Yield Model

A 1,000 recruit equilibrium yield model, as described by Ricker (1975), was applied to simulate fishery and population effects of an existing 305 mm verses an alternative 254 mm minimum length limit for smallmouth bass. The 305 mm and 254 mm minimum length limits were modelled as recruitment to the fishery at ages 5 and 4, respectively. Model relationships were entered on a computer spreadsheet to assist in calculations (Appendix B).

The average weight at age input variable was based on length at age and weight-length data. Natural mortality (M) and fishing mortality (F) were based on mortality estimates discussed in the smallmouth bass mortality section of this document. For the 254 mm limit option, the survival rate (S) at age 4 was reduced to .50, with fishing mortality (F) equal to natural mortality (M). This increase in mortality above observed conditions was applied to construct a conservative model that accounted for a potential increase in F due to a higher harvest rate for younger bass.

Limnology

Six limnological sampling stations were established at locations used in previous studies (Falter et al. 1979; Falter 1982; Horton 1981)(Figure 1). Four stations were on the main body of the reservoir at river kilometers five (RK5), 31 (RK31), 56 (RK56), and 70 (RK70). Two stations were located in major arms of the reservoir: 6 km into the Elk Creek arm (EC6), and 2 km into the Little North Fork of the Clearwater River arm (LNF2).

Composite water samples were collected from depths of 3 m, 6 m, 9 m, 12 m and the surface using a Kemmerer bottle at RK5, RK56, and EC6. Samples were placed in a splitter bucket and churned. One liter of composite water sample was used to measure chlorophyll a content. This water was filtered onto an Advantec 0.45 um filter (47 mm in diameter) using a Gast 1/4 horsepower vacuum pump powered by a portable generator. The filter was then placed in a petri dish, covered with aluminum foil, and frozen. Two ml of sulfuric acid was added to 1 liter of composite water and bottled for later analysis of total phosphorus. Two hundred ml of distilled water was used to wet and clean a Metricel membrane filter (6A-6) of 0.45 um, 47 mm in diameter. The distilled water was then discarded. Three hundred ml of composite water was filtered. One hundred fifty ml of filtrate was frozen for analysis of dissolved ortho-phosphate. The remaining 150 ml was treated with 0.3 ml of sulfuric acid, frozen and analyzed for dissolved total phosphorus. In 1988, the samples were analyzed by the Idaho Public Health Department, in Lewiston. In 1989, analysis was conducted by Eastern Washington State University and in 1990, by Idaho Department of Health and Welfare, in Coeur d'Alene.

Transparency was measured at each of the six sites with a 20 cm Secchi disk. Dissolved oxygen and temperature readings were taken at the surface, 1 m, and at even meter depths to 60 m using a Yellow Springs Instrument Company model 57 meter.

Recording TempMentor thermographs were placed on the reservoir bottom near the shore at Merry's Bay, Elk Creek Arm (river km 1.1) and Cold Creek. Depth at set time was recorded so that daily pool elevation data could be used to monitor depth changes corresponding to pool fluctuations. Hourly temperatures were recorded from March through October 1991. Mean daily temperatures were calculated from hourly data. Mean daily temperatures were plotted with the daily depth of the thermograph to characterize the effects that fluctuating pool levels have on the near-shore temperature regime. Thermographs were relocated intermittently to maintain a target depth range of 1 to 7 m.

Creel Survey

We used a stratified two-stage probability creel survey design to count and interview anglers (Malvestuto 1983). Sample days were stratified into weekends and weekdays. The reservoir area was subdivided into three sample sections: Dworshak Dam to dent Bridge; Dent Bridge to Grandad Bridge, and; Grandad Bridge to the end of slackwater (Figure 1). Sample areas were selected using non-uniform probabilities based on expected relative fishing pressure (Statler 1990).

Five weekdays and five weekend days per month were sampled to: interview anglers for catch rates (fish per hour); count boat and bank anglers to determine fishing pressure (angler-hours), and; collect pertinent biological data from the creel. One morning angler count and one evening count were made by boat on each sample day. The morning angler count time was randomly selected and the interval between the morning and evening counts varied from 4.0 to 7.5 h, depending on day length.

Reservoir drawdown eliminated access to all boat ramps except the Big Eddy Ramp during winter. Under these conditions, a creel survey clerk remained at the boat ramp throughout the day and obtained completed trip information from all boat anglers. A second clerk traveled to the Dent area and Canyon Creek area to check bank anglers.

Monthly estimates of angler-hours were calculated as the product of the mean number of anglers per hour (mean instantaneous count) and the total monthly daylight hours (weekday and weekend). Catch rates were calculated for each species, as well as each identifiable hatchery rainbow trout strain, from monthly summaries of interview data. Monthly catch estimates were calculated as the product of the monthly catch rates of each species (or strain) and estimated effort.

Lengths, weights, scale samples, and stomach samples were taken from specimens observed in the creel.

The creel survey was conducted jointly by the IDFG and the NPT Department of Fisheries Management.

RESULTS

Kokanee

Abundance

Total kokanee abundance within Dworshak Reservoir has ranged from over 1.2 million fish (224/hectare) in 1988 to a low of 365 thousand kokanee (68/hectare) in 1991 (Table 3). Kokanee of age 3 or older were quite rare and ranged from 0 to 12 thousand fish in our estimates. Kokanee of age 2 and 3 were recruited to the fishery and ranged in densities from 32.4 fish/hectare during 1989 to 4.6 fish/hectare in 1991 (using only late June or July trawl data for consistency)(Table 3).

Kokanee abundance was estimated three times during the summer of 1989; on June 5-8, June 27-30, and September 25-28 (Table 3). Age 0 kokanee abundance increased progressively throughout the summer from 148 thousand to 294 thousand to 648 thousand. The increasing abundance of age 0 kokanee probably reflected the increased recruitment to our trawling gear. Density of maturing kokanee, however, declined throughout the summer from 175 thousand to 145 thousand to 45 thousand. Declining abundance was due to angler harvest and movements of kokanee out of the reservoir to spawn. Considering these two shifts in kokanee abundance, the most consistent time to examine year-to-year changes in abundance would be by using the July (and late June 1989) trawling results.

Kokanee abundance by age class and lake section was also highly variable (Table 4). For example, Section 1 had the highest densities of all age groups of kokanee during 1991 trawling. Age 0 kokanee, however, were more abundant in section 3 in 1990 and 1989. Age 1 kokanee were most abundant in section 1 during 1991, and 1989, in section 2 during 1990, and in section 3 during 1988.

Survival Rates

Kokanee survival rates were calculated to be as low as 2% for kokanee from age 2 to age 3 in 1990. Mean survival rates were 31%, 17% and 20% for kokanee from ages 0 to 1, 1 to 2, and 2 to 3, respectively (Table 5) (Figure 3).

Age, Growth, and Maturity

The Dworshak kokanee population was composed of four age classes; ages 0 to 3 (Figure 4). Kokanee older than age 3 were not documented during any sampling (based on scale analysis of trawl caught fish or otolith examination of kokanee spawners). Age 3 kokanee were only infrequently collected and constituted only 0.3% (1990) to 2% (1991) of the population (Table 3). Consistent with this finding, we found upon dissecting trawl-caught kokanee that nearly all were maturing at age 2.

During July 1988 and 1991 kokanee lengths at a given age were very similar (Figure 4). Modal length of age 0 kokanee was 40 - 60 mm, age 1 kokanee were 170 - 190 mm, age 2 kokanee were 270 - 280 mm, and age 3 kokanee were 300 - 310 mm. Corresponding growth rates were therefore 25 mm/month for age 0 fish, 12.9 mm/month for age 1 fish, 10.4 mm/month for age 2 fish, and 7.9 mm/month for age 3 fish (assuming an emergence date of mid-May).

A somewhat slower growth rate was documented for age 2 kokanee during 1989 (Figure 4). Modal length of this cohort was from 240 - 250

Table 3. Kokanee population estimates (thousands) in Dworshak Reservoir, Idaho, From 1988 to 1991.

Year Class[1] of kokanee	Year Estimated July 1991	September 1990	September 1989	Late June 1989	Early June 1989	July 1988
1990	132					
1989	208	978				
1988	19	161	648	294	148	
1987	6	11[2]	165	100	148	553
1986		3[2]	45	140	170	501
1985				5	5	144
1984						12
Totals	365	1,153	858	539	471	1,210
Number/ hectare	68	214	159	100	87	224
Age 2+3/hectare	4.6	2.6	8.3	26.9	32.4	28.9
Biomass (kg/hectare)	2.9	4.4	5.9	5.2		9.7

[1]Year class was defined as the year eggs were laid.

[2] Mature kokanee underestimated in September sampling.

Table 4. Densities (number/hectare) of kokanee in each section of Dworshak Reservoir, Idaho, 1991. Section 1 was from the dam to Dent Bridge, section 2 was from Dent Bridge to Grandad Bridge, and section 3 was from Grandad Bridge to the end of slack water.

	Densities				
	Age 0	Age 1	Age 2	Age 3	Total
July 8-12, 1991					
Section 1	28	50	6	2	86
Section 2	22	23	0	0	45
Section 3	17	27	3	0	47
September 17-20, 1990					
Section 1	143	14	2	0	159
Section 2	289	71	3	2	365
Section 3	345	35	0	0	380
September 25-28,1989					
Section 1	135	38	21	0	194
Section 2	172	53	8	0	233
Section 3	144	17	0	0	161
June 27-30, 1989					
Section 1	6	42	34	0	82
Section 2	20	16	25	2	63
Section 3	147	0	22	0	169
July 11-14,1988			Age 2+3		
Section 1	167	78	20		265
Section 2	49	96	17		162
Section 3	71	135	71		277

Table 5. Survival rates (%) for kokanee in Dworshak Reservoir, Idaho, 1989 to 1990, by age class.

Year of Estimate	Age Class		
	Age 0-1	Age 1-2	Age 2-3
1989	18	28	3
1990	55	11	2
1991	21	12	55
Mean	31	17	20

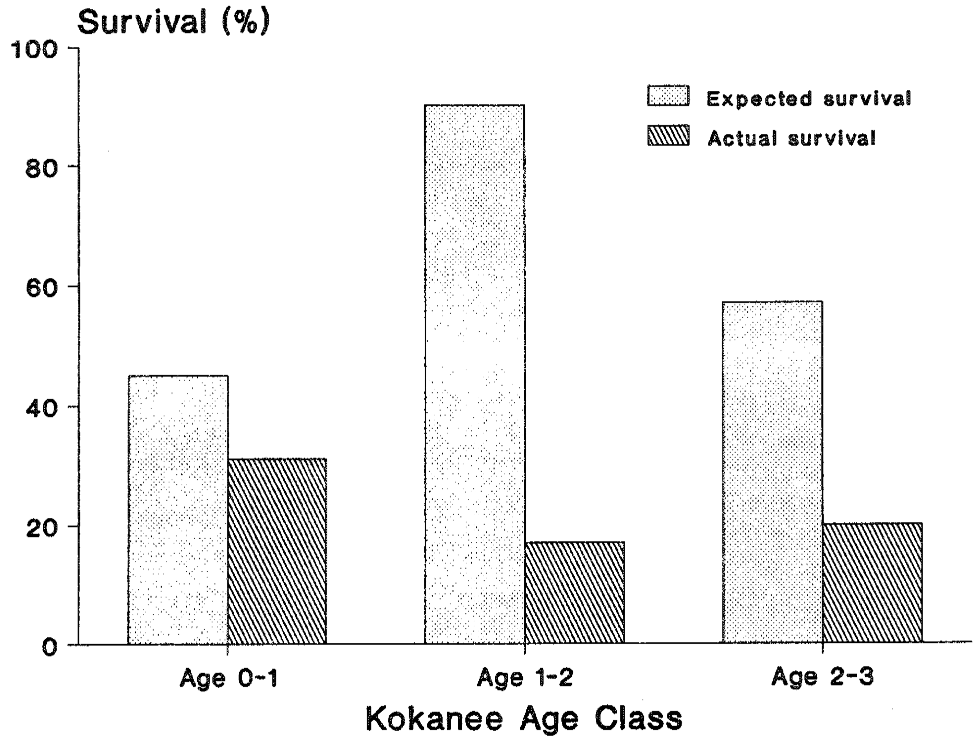


Figure 3. Mean survival rates of kokanee in Dworshak Reservoir, Idaho, 1989 to 1991 (actual survival), compared to mean survival rates from other waters (expected survival) (Rieman and Meyers 1990).

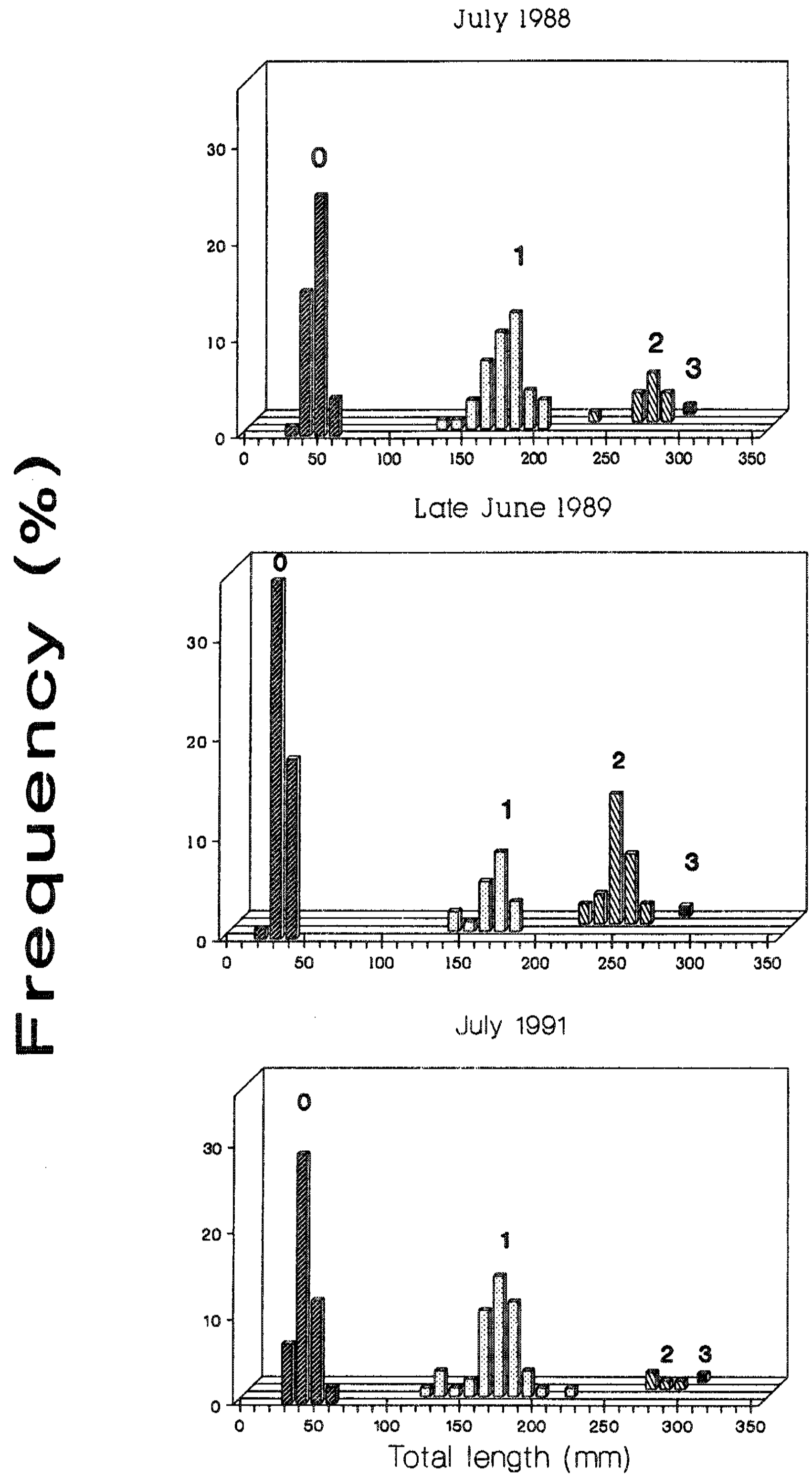


Figure 4. Length frequency distribution of kokanee caught by midwater trawl in Dworshak Reservoir, Idaho, 1988-1991.

mm for an overall growth rate of 9.4 mm/month. This was also the most abundant cohort of kokanee which numbered 501,000 fish at age 1 in 1988 (Table 3). Other age groups during 1989 had growth rates similar to those reported for 1988 and 1991.

Spawning Trends

Isabella Creek generally had the highest counts of kokanee of the surveyed streams. Numbers of spawners ranged from 2,250 fish in 1983 to 11,830 fish in 1989 (Table 6). Dog was the smallest stream surveyed and had the highest densities (on a per area basis) of any stream. The total number of kokanee in the three tributaries with the longest time-series data (Skull, Quartz, and Isabella Creeks) showed fluctuations in abundance of approximately an order of magnitude, 2,450 to 21,830 fish.

We found no spawning kokanee when surveying in November of 1987 (Table 6), indicating that the late spawning strain of kokanee had been extirpated from the system.

Mean total length of kokanee in the spawning runs ranged from 285 mm (in 1988 and 1989) to 370 mm (in 1983) (Figure 5). Length was inversely related to spawner abundance. During 1991 spawners were primarily age 2 (and averaged 305 mm) although some age 1 males were present and a few age 3 kokanee were present (Figure 6).

Entrainment

The number of kokanee counted below Dworshak Dam during trend surveys ranged from 0 to 641 fish. This highest count was observed on January 22, 1991 at a discharge from the dam of 297 m^3/s. Counts were very weakly correlated with date (r^2=0.07), discharge from the dam (r^2=0.11), reservoir elevation (r^2=0.01), or depth of water withdrawal (r^2=0.01) (Figures 7 and 8).

<u>Trout</u>, <u>Bass</u> <u>and</u> <u>Forage</u> <u>Species</u>

Abundance

A total of 738 fish were gill netted from 1988 through 1990 during 1,041.8 net-hours of effort (Appendix C). Squawfish, suckers and smallmouth bass consistently dominated gill net catches. Contributions of kokanee were seasonally pronounced with the interception of migrating adults during late summer and early fall.

Annual reservoir-wide catch rates for all species combined during the June through September sampling period were .86, 1.28 and .86 fish/h for 1988, 1989 and 1990, respectively. Corresponding catch rates exclusive of hatchery rainbow trout were .71, 1.27 and .84 fish/h for 1988, 1989 and 1990, respectively.

Historical comparisons of gill net catches for all species excluding hatchery rainbow trout indicate that catch rates peaked a few years after initial inundation and then dramatically declined (Figure 9).

Catch rate and relative abundance trends per species show that redside shiners were the most abundant species through 1976 (Figures 10 and 11). This species has since declined to be virtually nonexistent in Dworshak Reservoir. A collection of 8 redside shiners near the end of slackwater (Salmon Landing) on June 26, 1990 was the only documented occurrence of this species during 1988-90 sampling.

Table 6. Number of spawning kokanee observed in selected tributaries to Dworshak Reservoir, Idaho, 1981 to 1991.

							Date	Surveyed			
Stream	9/81	9/82	9/83	9/84	9/85	9/87	11/87	9/88	9/89	9/90	9/91
Isabella	4,000	5,000	2,250	9,000	10,000	3,520	0	10,960	11,830	10,535	4,053
Skull	3,220	4,500	135	2,200	8,000	1,351	0	5,780	5,185	3,219	1,249
Quartz	850	1,076	66	1,000	2,000	1,477	0	5,080	2,970	1,702	693
Dog						700	0	1,720	1,720	1,875	590
Break-fast						23[1]		14,760[1]	14,402[1]	1,149[1]	3,557
Beaver	2,117	4,000	384		8,000		0	1,700[1]	2,362[1]		
Elk							0	30[1]			
Total of Isabelle, Skull, Quartz	8,070	10,576	2,451	12,200	21,000	6,348	0	21,827	19,985	15,456	5,995

[1] Surveys were not conducted to the end of the spawning run.

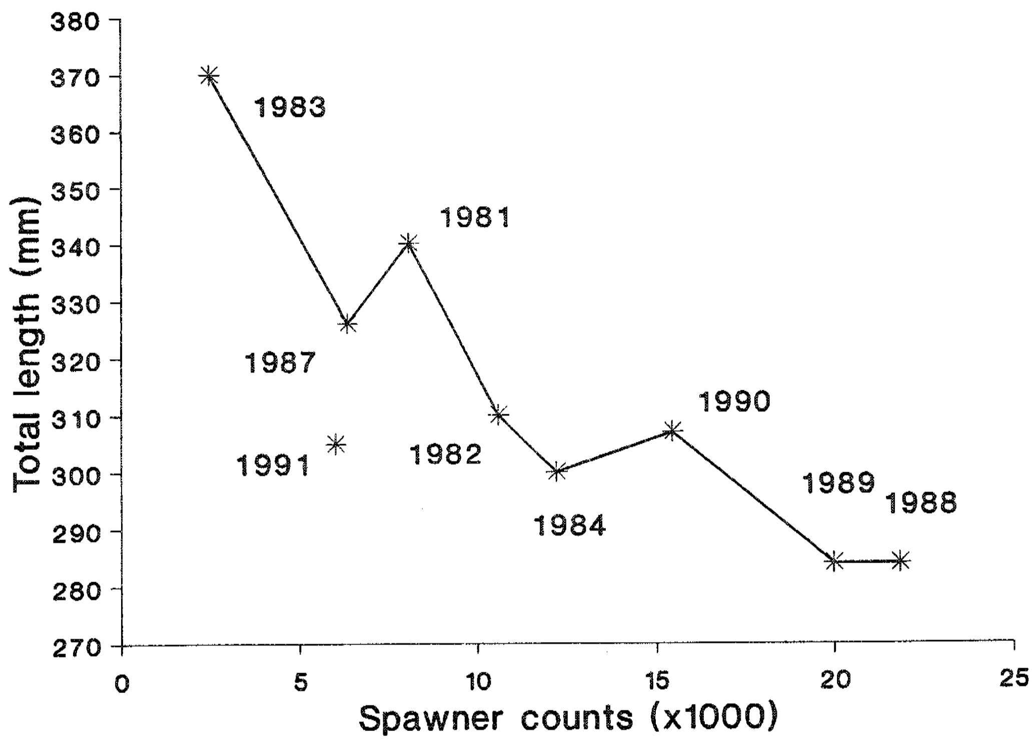


Figure 5. Total mean length of kokanee spawners counted in Isabella, Quartz, and Skull Creeks, tributaries to Dworshak Reservoir, Idaho, from 1981 to 1991.

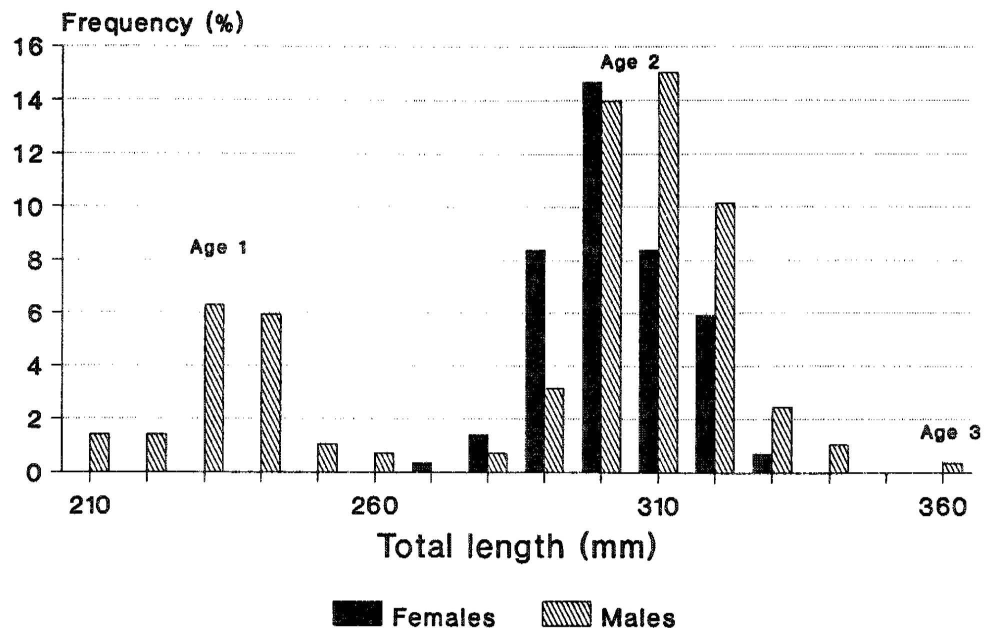


Figure 6. Age and sex of kokanee spawners from Dworshak Reservoir, Idaho in Isabella, Quartz and Skull Creeks, 1991.

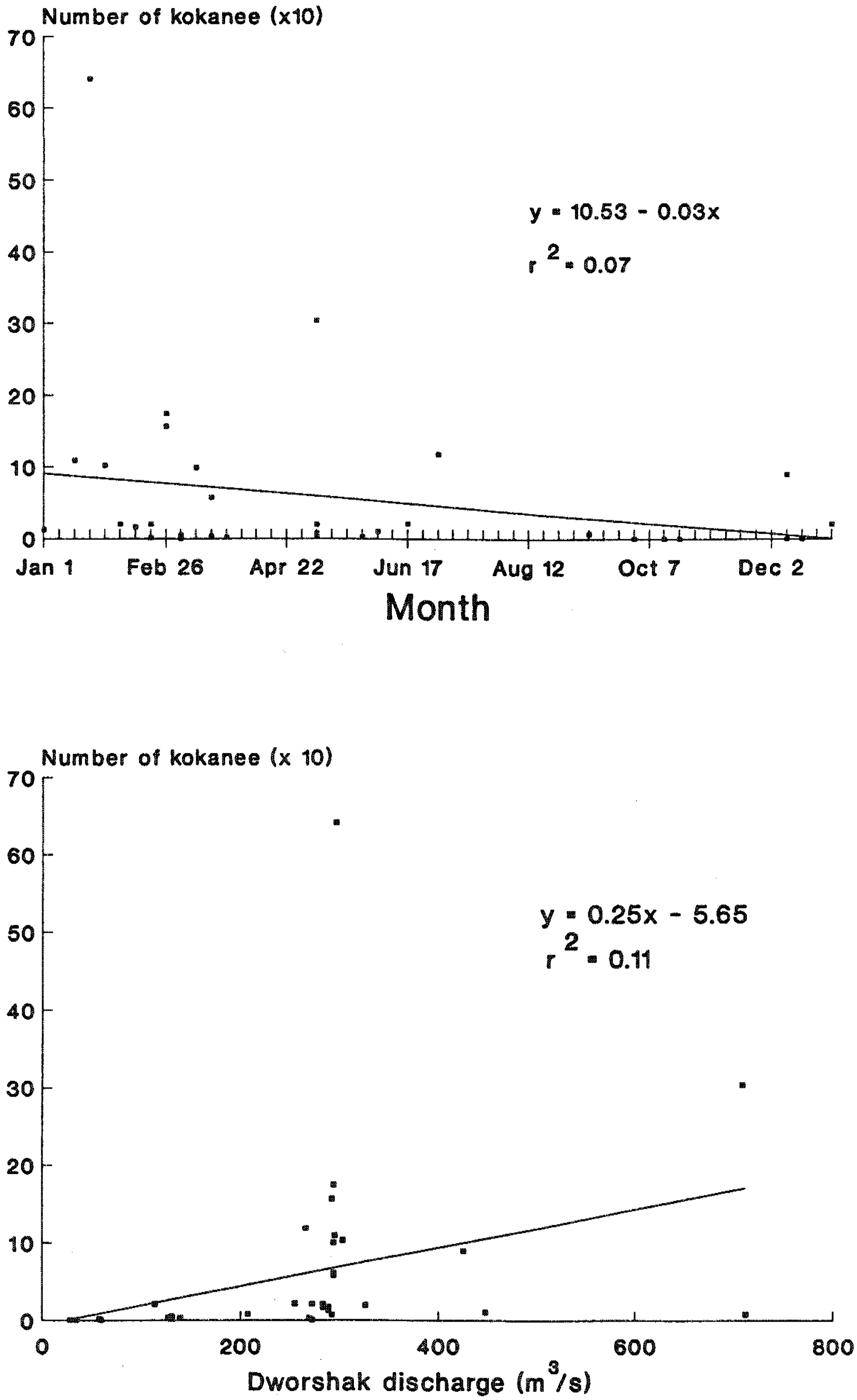
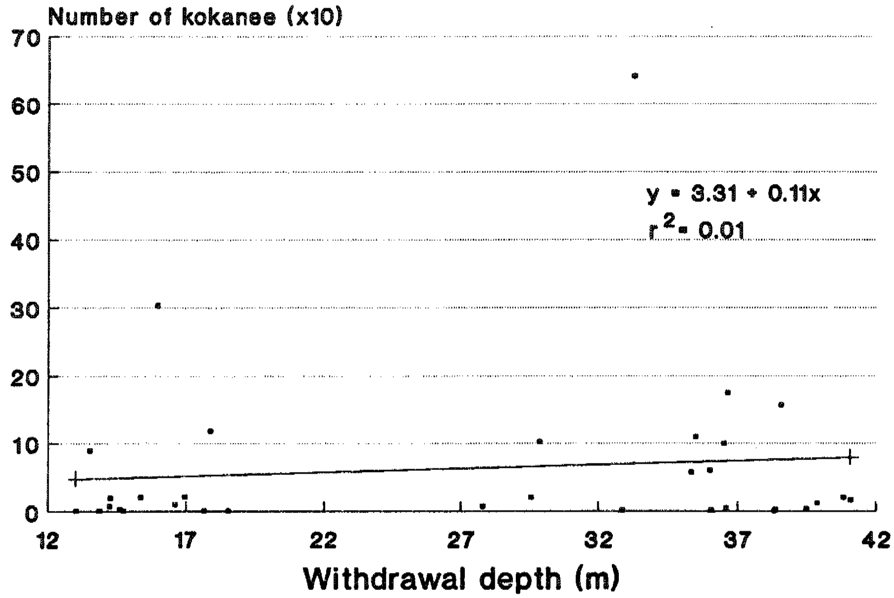


Figure 7. Relationship between date and discharge, and number of kokanee counted by snorkeling in the North Fork Clearwater River below Dworshak Dam, Idaho, 1990 and 1991.



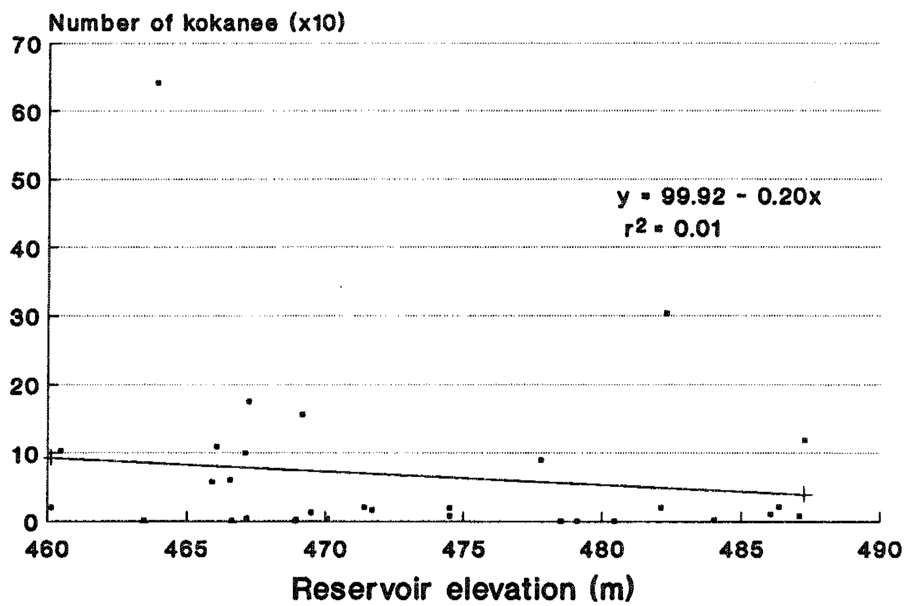


Figure 8. Withdrawal depth and reservoir elevation versus snorkel counts of kokanee below Dworshak Dam, Idaho, 1990 and 1991.

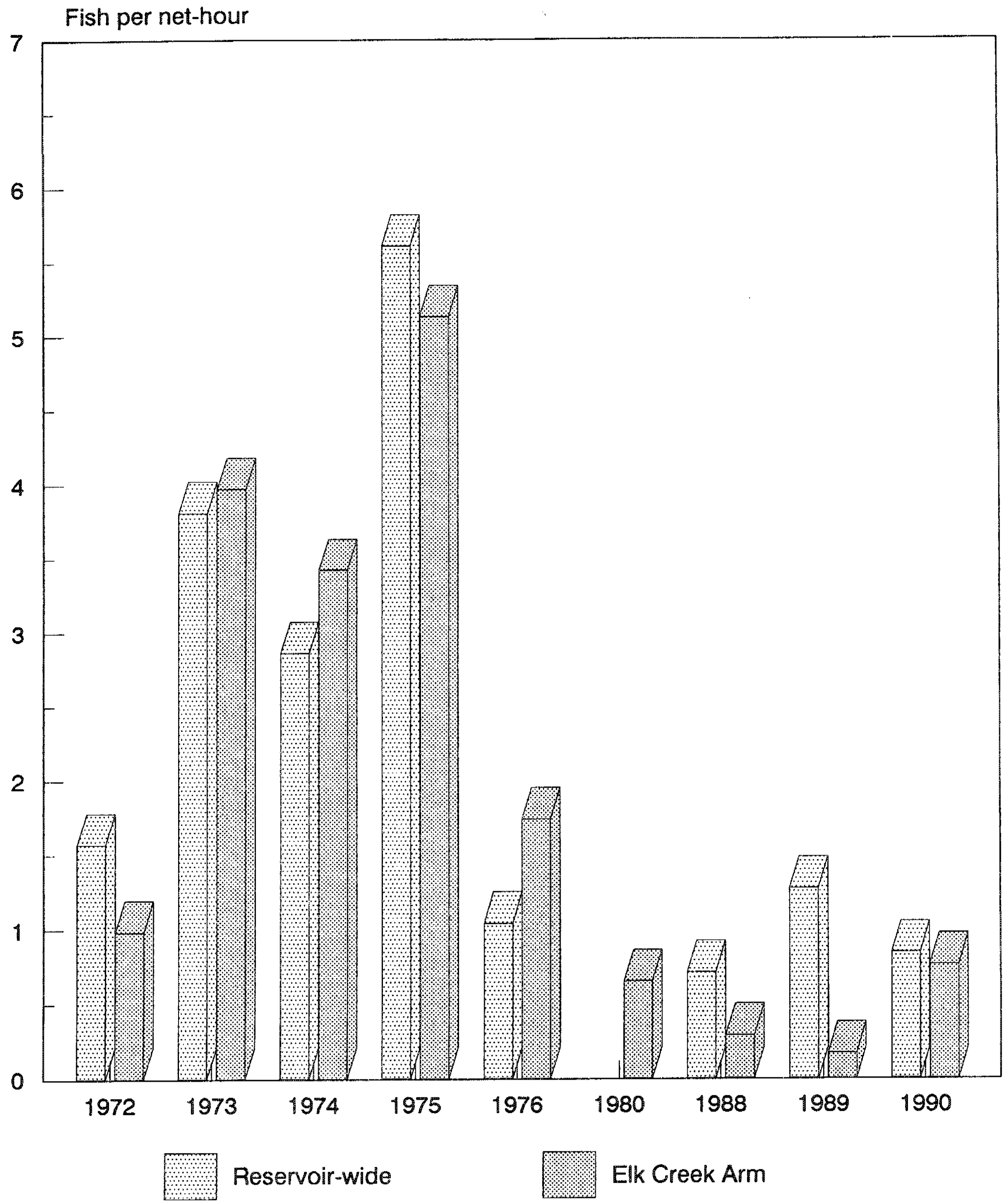


Figure 9. Reservoir-wide and Elk Creek Arm gill net catch rates for all species combined, excluding hatchery rainbow trout, from 1972 through 1990, Dworshak Reservoir, Idaho.

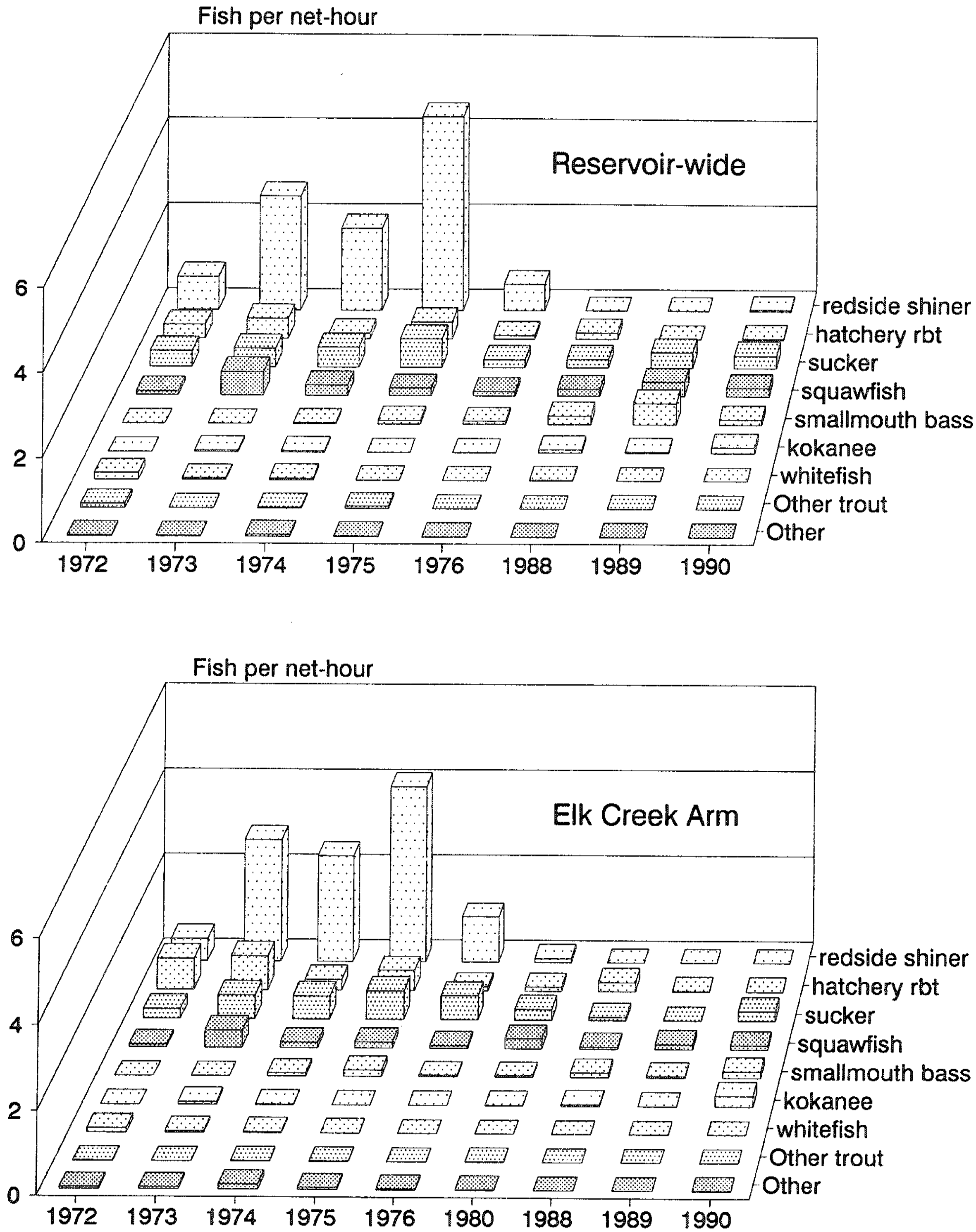


Figure 10. Annual reservoir-wide and Elk Creek Arm gill net catch rates by species for the June through September sampling period, 1972 through 1990, Dworshak Reservoir, Idaho.

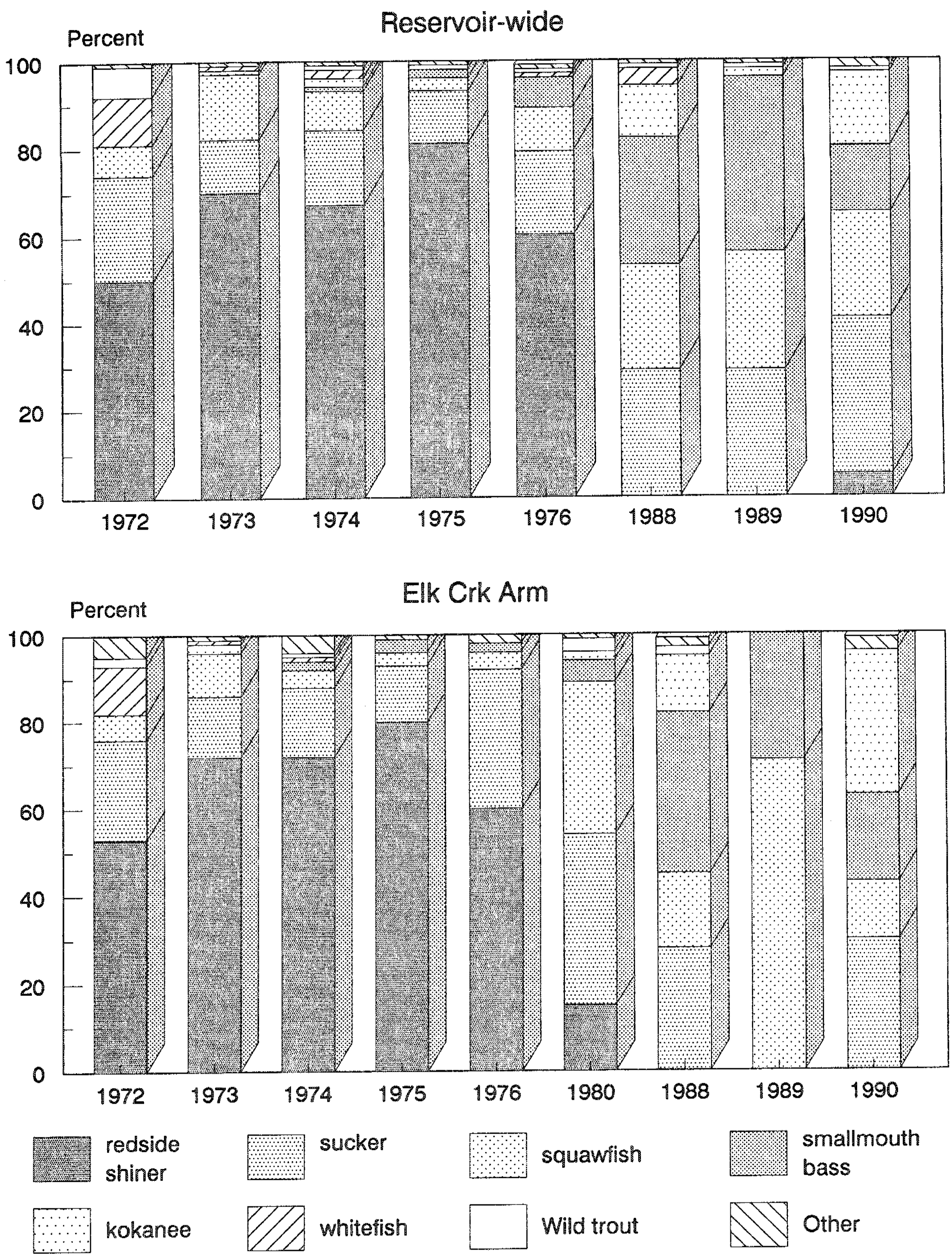


Figure 11. Annual reservoir-wide and Elk Creek Arm percent species composition, hatchery rainbow trout excluded, for the June through September sampling period, 1972 through 1990, Dworshak Reservoir, Idaho.

Smallmouth bass did not enter experimental gill net catches until eight specimens were collected by Pettit et al. (1975) in 1974. The following year, another 16 smallmouth bass were netted (Pettit 1976). These early collections were all taken from the Elk Creek Arm. Two smallmouth netted by Pettit (1977) at the Boathouse Creek confluence (river km 54.0) during 1976 were the first specimens taken upstream from the Elk Creek Arm.

Black crappie Pomoxis nigromaculatus and Pumpkinseed Lepomus gibbosus were added to the fish species list for Dworshak Reservoir as a result of project gill netting (Statler 1989, 1990).

Limited gill net and hook-and-line collections near river km 83 during May and June, 1990, indicated a high incidence of cutthroat trout-rainbow trout hybridization. Out of 11 naturally produced Oncorhynchus spp. collected, 8 were cutthroat trout-rainbow trout hybrids and 3 were natural/wild rainbow trout. Specimens with typical westslope cutthroat trout Oncorhynchus clarki lewisi morphological characteristics were taken during other gill net sets and were observed in the creel.

Growth

Hatchery Rainbow Trout Strains - Fish lengths obtained during the 1988-89 and 1989-90 winter rainbow trout fishery periods indicated that growth was virtually identical for the two strains (Shasta and Arlee) of rainbow trout for both test years (Figure 12). Condition (K) factors among the two test strains for the same collection periods were also comparable (Table 7).

Shasta and Arlee strain rainbow trout were again planted in 1990, but without marks or tags to allow strain identification in the field. The 1990 release group was planted in May, one month earlier than the 1988 and 1989 releases. The 1990 release group provided the largest fish to the following winter's fishery, although at release they were 20 mm and 19 mm smaller than the 1988 and 1989 release groups, respectively (Figure 13).

Smallmouth Bass - Linear regression of body-scale relationships showed strong correlations based on 1988 (r^2=.91, n=66) and 1989 (r^2=.96, n=176) collections (Figure 14). Horton (1981) reported a strong body-scale correlation (r^2=.94, n=105) for bass collected during 1980.

Mean length at age data indicated excellent early growth, averaging 99 mm and 90 mm at age 1 for 1988 and 1989 samples, respectively (Table 8). Von Bertalanffy growth equations for 1988 and 1989 are comparable, and both indicate a considerable reduction in smallmouth bass growth rate and ultimate size since 1980 (Figure 15). Expected age at recruitment to legal size (305 mm) is age 5.

Food Habits

Rainbow Trout - Analysis of 23 stomachs from Shasta and Arlee strain rainbow trout collected during 1988 showed considerable similarity in food habits of the two strains, with Cladocera and terrestrial insects being of major importance (Figure 16)(Appendix D).

Cladocera, Hymenoptera and Homoptera registered the highest C.I. values for both strains. These three taxa also comprised 73.2% and 37.5% of the total volume in the Arlee and Shasta samples, respectively. Volumetric analysis of the Shasta samples was more diverse, with

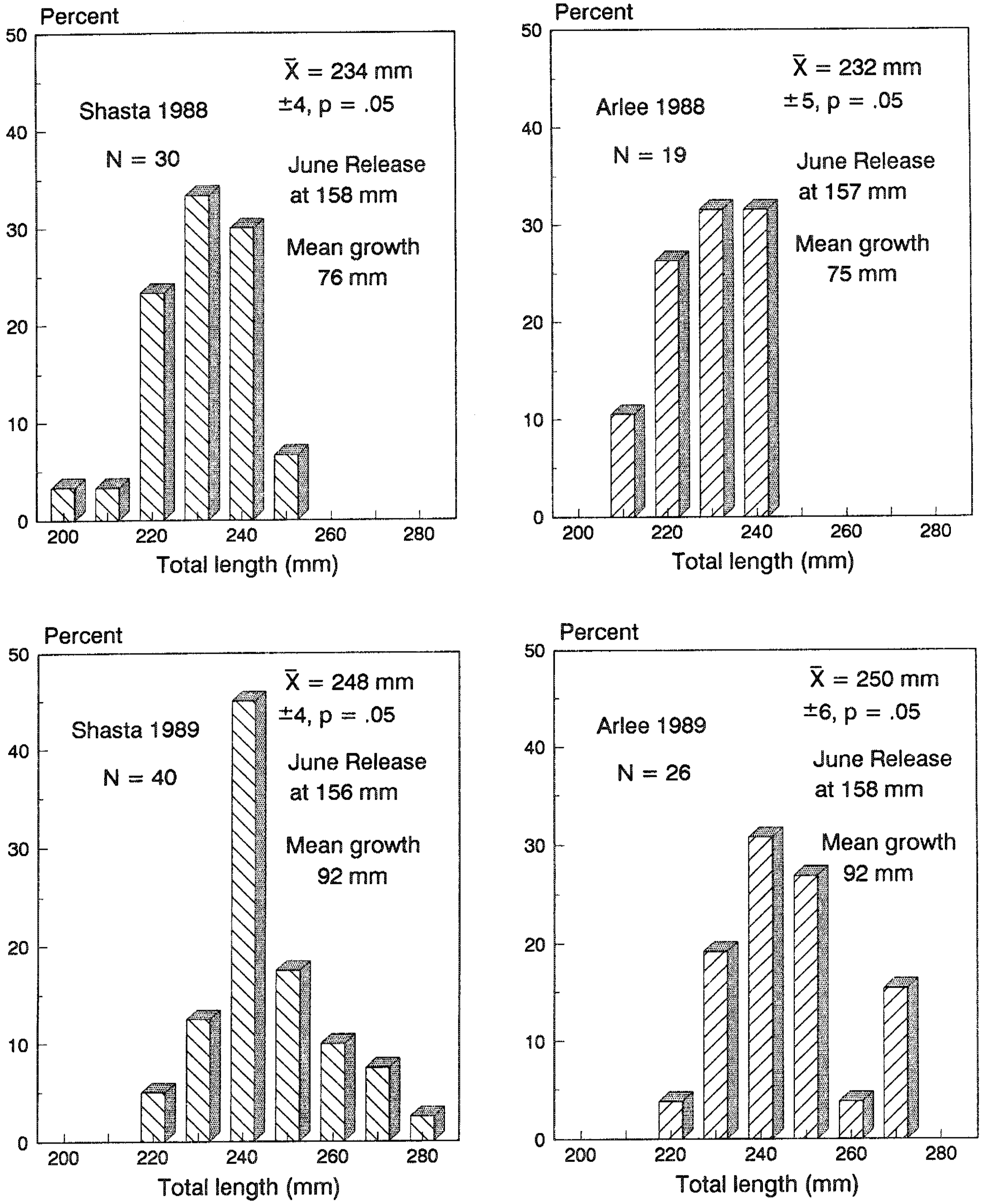


Figure 12. Length frequencies, mean lengths and length increases for 1988 and 1989 release groups of Shasta and Arlee strain rainbow trout from gill netting and the creel during the 1988-89 and 1989-90 winter (November-February) fisheries, Dworshak Reservoir, Idaho.

Table 7. Mean condition (K) factors and confidence intervals ($p=.05$) for 1988, 1989 and 1990 release groups of Shasta and Arlee strain rainbow trout during the winter fishery (November-February) following release, Dworshak Reservoir, Idaho.

Release year	Strain	Mean K factor (X 10^7)
1988	Shasta	89.8 ± 4
1988	Arlee	89.1 ± 3
1988	Shasta and Arlee combined	89.6 ± 3
1989	Shasta	84.2 ± 3
1989	Arlee	89.1 ± 4
1989	Shasta and Arlee combined	86.2 ± 2
1990	Shasta and Arlee combined	87.8 ± 3

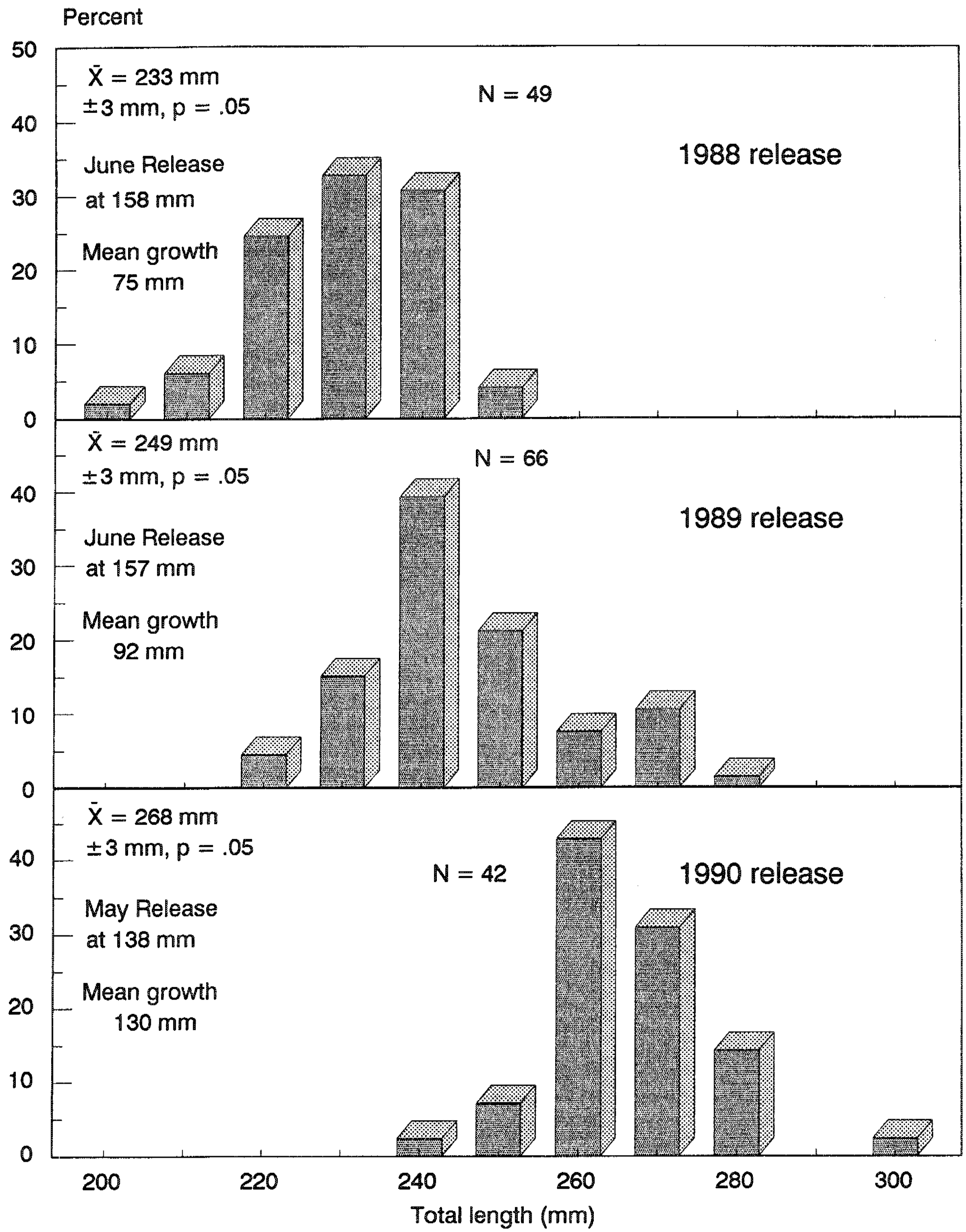


Figure 13. Length frequencies and mean lengths for 1988, 1989 and 1990 release groups of Shasta and Arlee strain rainbow trout (combined) during the winter fishery period (November through February) following release, with incremental growth from spring release to the winter fishery, Dworshak Reservoir, Idaho.

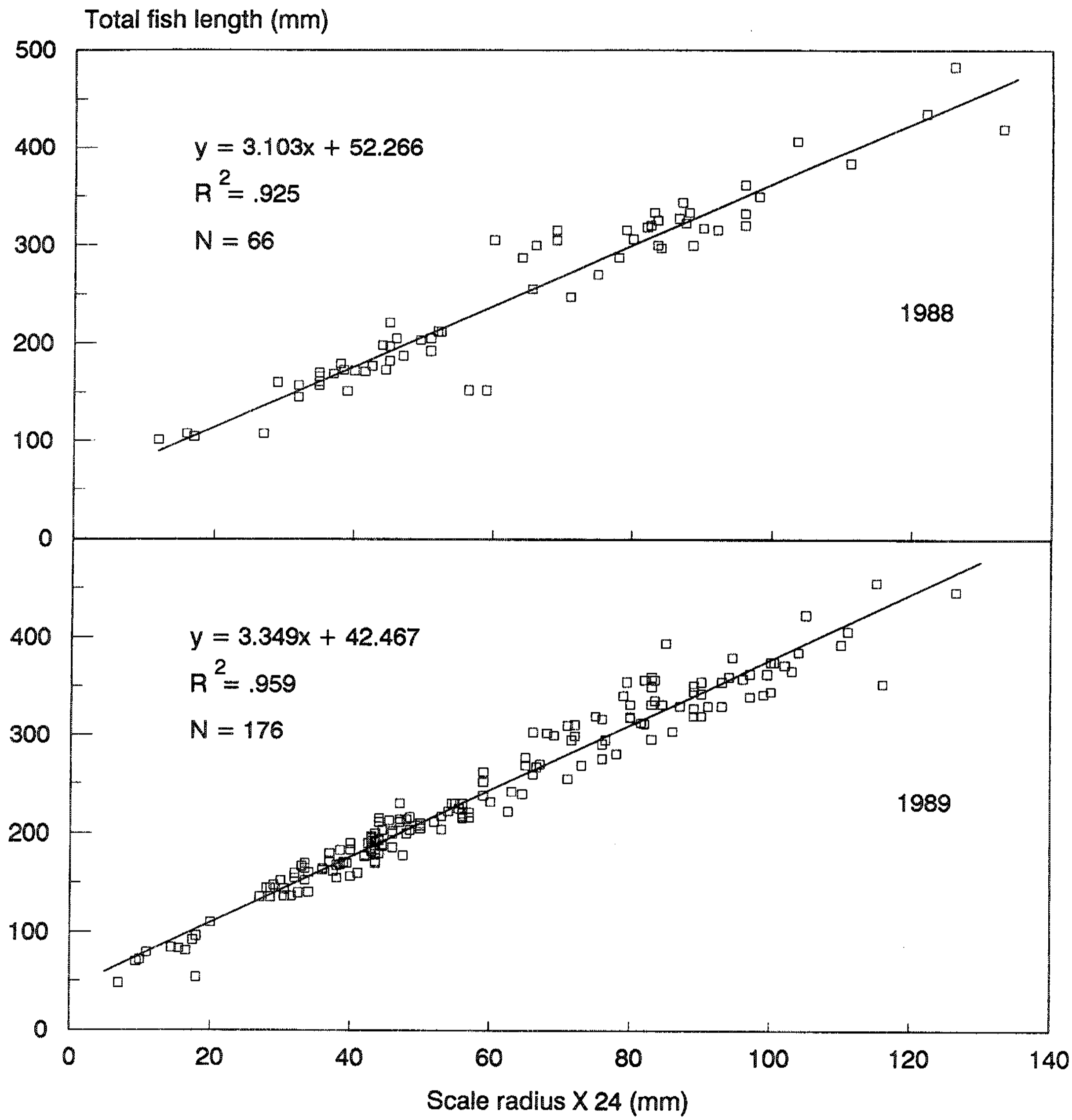


Figure 14. Body-scale regressions for smallmouth bass collected during 1988 (n=66) and 1989 (n=176), Dworshak Reservoir, Idaho.

Table 8. Calculated total lengths (mm) at each annulus and annual increments of growth for smallmouth bass sampled in 1988 (n=63) and 1989 (n=168), Dworshak Reservoir, Idaho.

				Calculated mean length at each annulus (mm)									
Sample Year	Age	Year class	Number of fish	1	2	3	4	5	6	7	8	9	10
1988	1	1987	14	106.0									
	2	1986	11	96.0	157.4								
	3	1985	20	98.2	178.8	241.8							
	4	1984	7	95.8	163.7	225.7	284.6						
	5	1983	6	96.5	157.4	234.2	292.8	337.2					
	6	1982	4	98.1	163.8	214.9	262.9	307.1	343.3				
	7	1981	0										
	8	1980	1	103.6	134.4	209.6	267.7	298.4	370.2	428.3	462.5		
1989	1	1988	17	97.3									
	2	1987	39	97.0	155.6								
	3	1986	44	89.9	160.7	199.7							
	4	1985	26	86.4	164.2	227.4	273.8						
	5	1984	21	83.3	160.5	216.3	262.2	302.0					
	6	1983	12	88.1	146.1	196.3	256.8	302.2	334.2				
	7	1982	8	81.1	144.9	203.3	258.0	305.2	344.9	381.2			
	8	1981	0										
	9	1980	0										
	10	1979	1	85.6	143.1	189.9	233.1	267.2	314.0	366.1	394.9	418.2	447.0
Number of fish													
		1988		63	49	38	18	11	5	1	1		
		1989		168	151	112	68	42	21	9	1	1	1
Weighted mean length													
		1988		99.2	167.1	234.0	281.6	322.7	348.7	428.3	462.5		
		1989		90.4	157.8	209.0	264.7	301.8	337.3	379.5	394.9	418.2	447.0
Mean growth increment													
		1988		99.2	67.9	66.9	47.6	41.1	26.0	79.6	34.2		
		1989		90.4	67.4	51.2	55.7	37.1	35.5	42.2	15.4	23.3	28.8

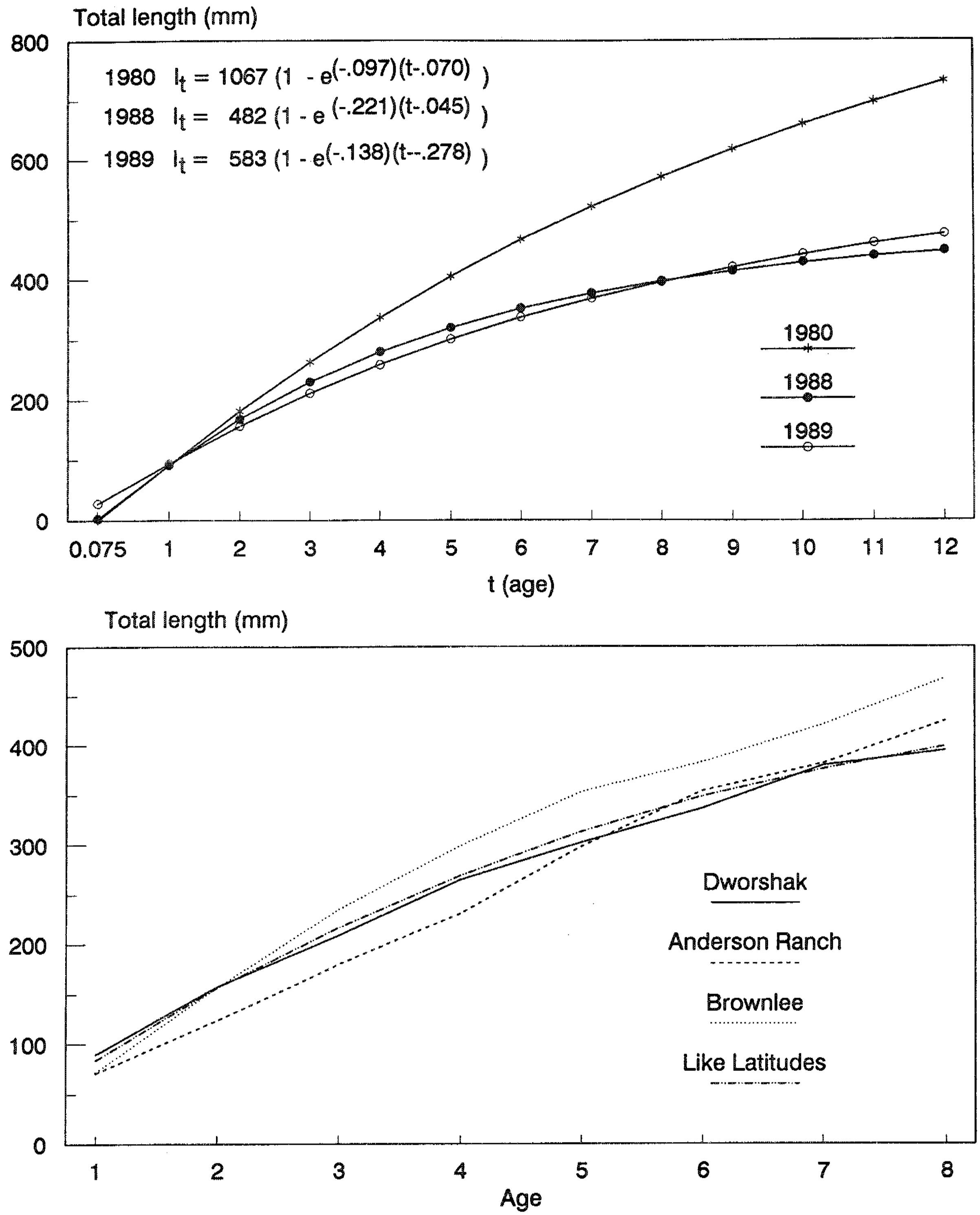


Figure 15. Von Bertalanffy growth equations for Dworshak Reservoir, Idaho, smallmouth bass based on collections during 1980 (Horton 1981), 1988 and 1989, and comparison of mean lengths at age for smallmouth bass from Dworshak, Anderson Ranch (Partridge 1987), and Brownlee (Rohrer and Chandler 1985) Reservoirs, Idaho, and from waters at similar latitudes (Bennett and Dunsmoor 1986).

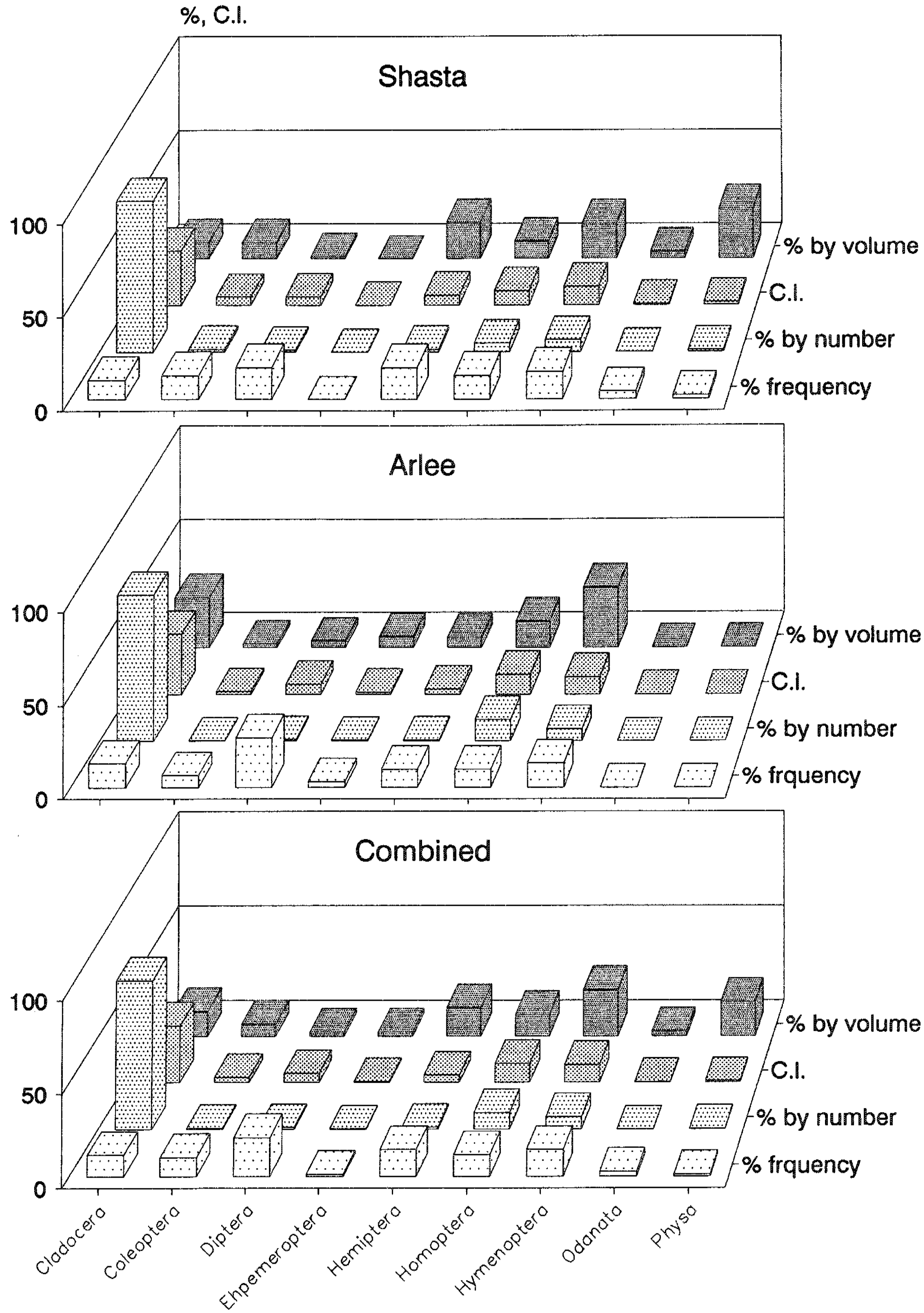


Figure 16. Food items contained in stomachs of Shasta and Arlee strain rainbow trout collected in 1988 (n=23) by percent frequency of occurrence, percent by number, Coefficient of Importance (C.I.) and percent by volume, Dworshak Reservoir, Idaho.

substantial contributions from Acanthochitonida (Physa sp.), Hemiptera and Coleoptera. Although Physa sp. ranked the highest percent by volume in the Shasta samples, this taxon occurred in only one sample. Diptera, Hemiptera and Coleoptera occurred frequently in both Shasta and Arlee samples, but in low numbers per sample.

Stomach samples from the smallest fish sampled (160-180 mm) contained Cladocera and Diptera exclusively (Figure 17). Cladocera were not found in sample size classes over 230 mm. The one occurrence of Physa sp. was from the largest trout sampled (280 mm). Diptera were utilized over the widest range of trout size classes (160-260 mm).

Smallmouth Bass - A total of 90 smallmouth bass stomachs were analyzed for food content in 1988 and 1989. Stomachs were empty in 20% of the samples taken in both years.

Fish comprised the highest percent food composition by volume for 1988 and 1989 and were forage for a broad size range of smallmouth bass (Figures 18 and 19). An assortment of fish species were utilized by bass, including northern squawfish, salmonids, brown bullhead, sculpin, redside shiner, peamouth and smallmouth bass (Figure 20). Larval squawfish were used heavily by young-of-the-year bass. Predation on salmonids was noted for bass ≥ 260 mm.

Crayfish (Pacifasticus leniusculus) were present in 1989 samples, but absent in 1988 collections. Hymenoptera, Diptera, Trichoptera and fish occurred most frequently in the highest numbers per sample during 1988, thus registering the highest C.I. values (Appendix E). The top C.I. rankings from 1989 samples were Ephemeroptera, fish, Hemiptera and Diptera. C.I. values usually ranked closely with volume data. An exception is noted for Decapoda which ranked seventh for C.I. and third for percentage volume in 1989.

Smallmouth Bass Mortality

Catch curve analysis for 242 smallmouth bass sampled during 1989 conveys an estimated instantaneous mortality rate (Z) of .495 (Figure 21). Estimates for survival rate (S) and total actual mortality (A) are .610 and .390, respectively. Segregated analysis for the unexploited portion of the population (ages 0 through 4) provides nearly identical mortality indices.

A total of 34 smallmouth bass ≥305 mm were marked with Floy tags offering a $5.00 reward for return of the tag. Five of the 34 were returned. Because an estimated 24.1% of the smallmouth bass harvest occurred prior to marking, an adjustment in tag return equivalents was calculated to correct for pre-tagging exploitation, as follows:

$$\frac{5}{X} = \frac{75.9}{100}$$

Where X = adjusted tag equivalents = 7.

The estimated 1989 exploitation rate (u) for legal size bass, with the above correction factor, is 7/34 = .206. The estimated instantaneous fishing mortality (F) equals .261 and instantaneous natural mortality (M) equals .234.

Smallmouth Bass Length-Weight Indices

Proportional Stock Density - Gill netting and electro-fishing during 1989 produced a total of 104 smallmouth bass ≥180 mm and 24 bass

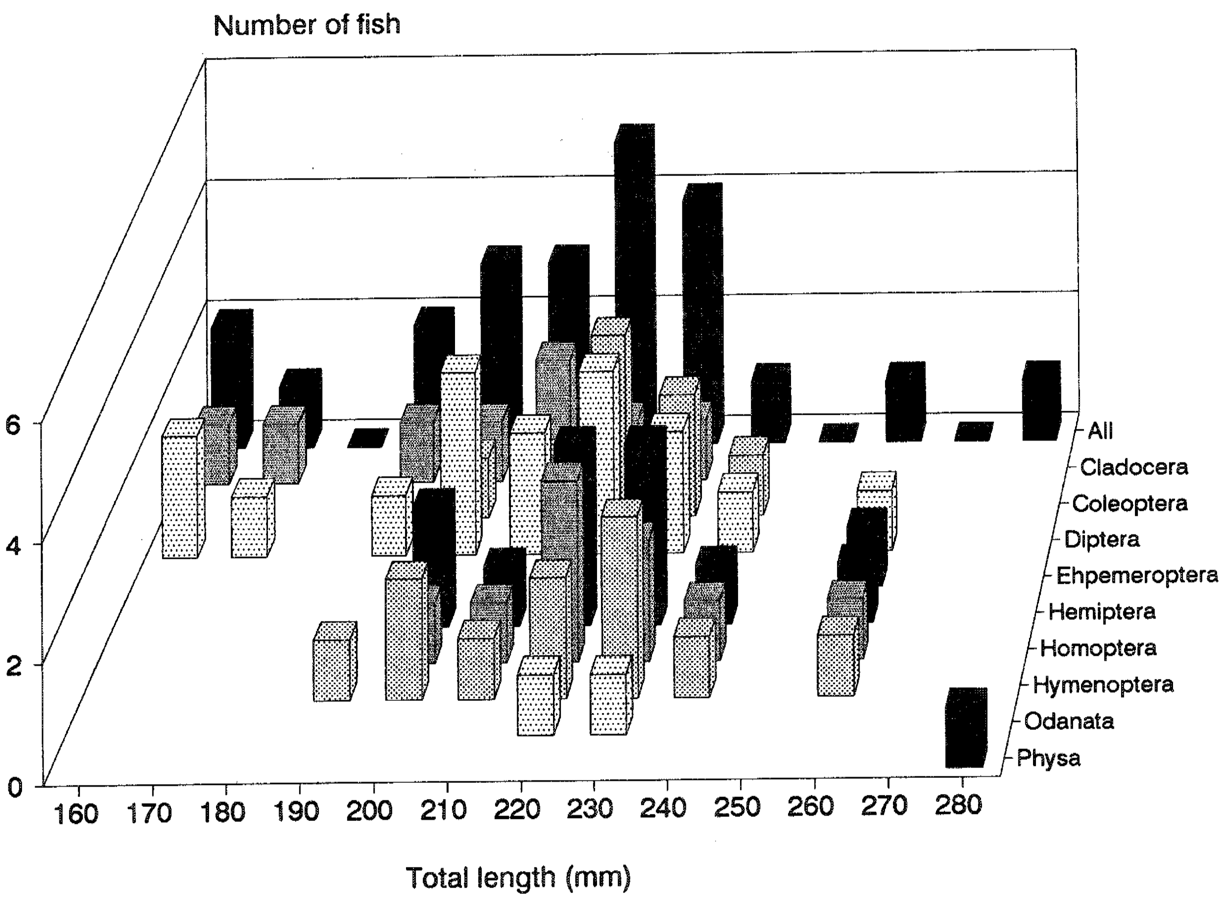


Figure 17. Length frequencies of Shasta and Arlee strain rainbow trout (combined) analyzed for food contents in 1988 (n=23) and number of fish per 10 mm size group containing specific food taxa, Dworshak Reservoir, Idaho.

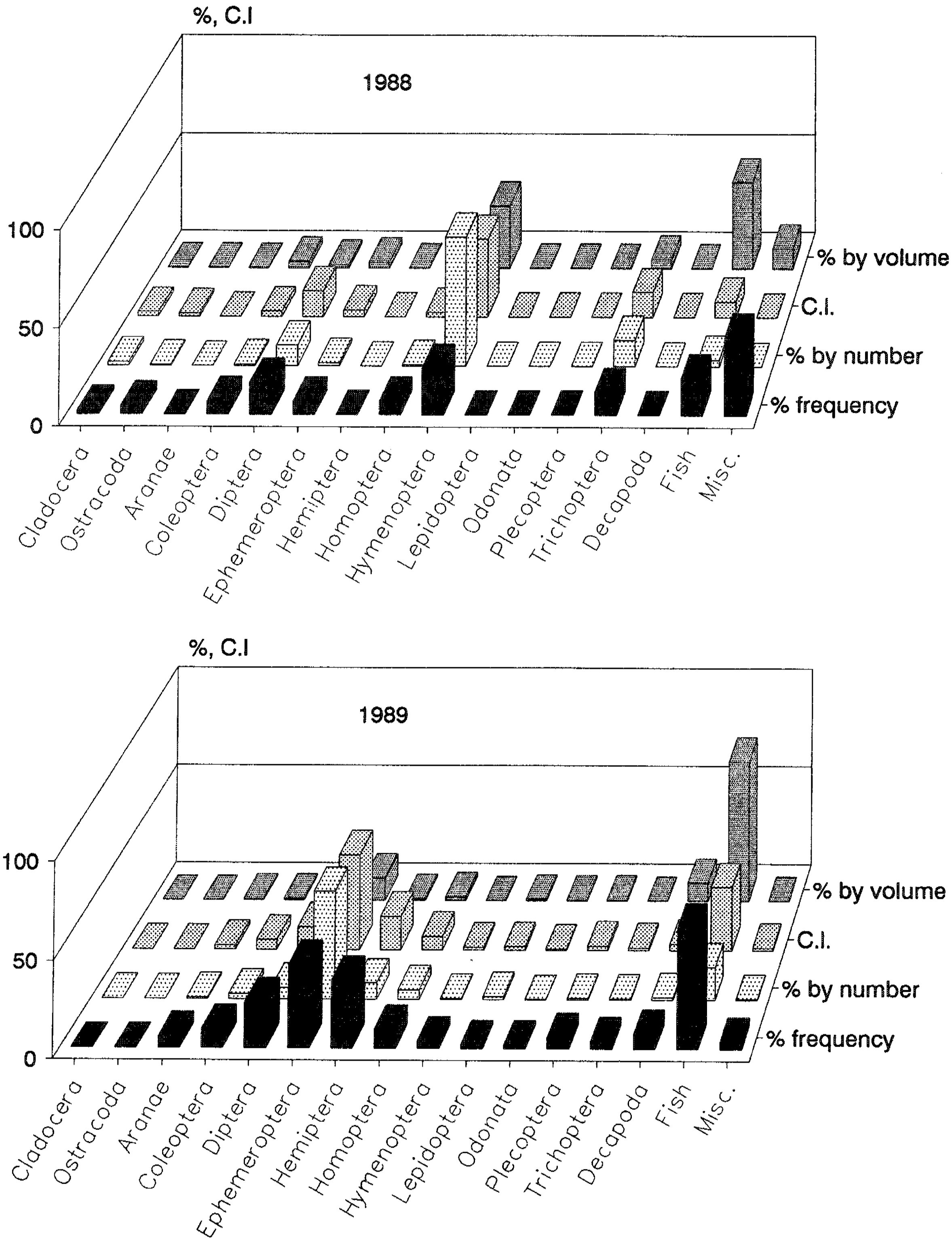
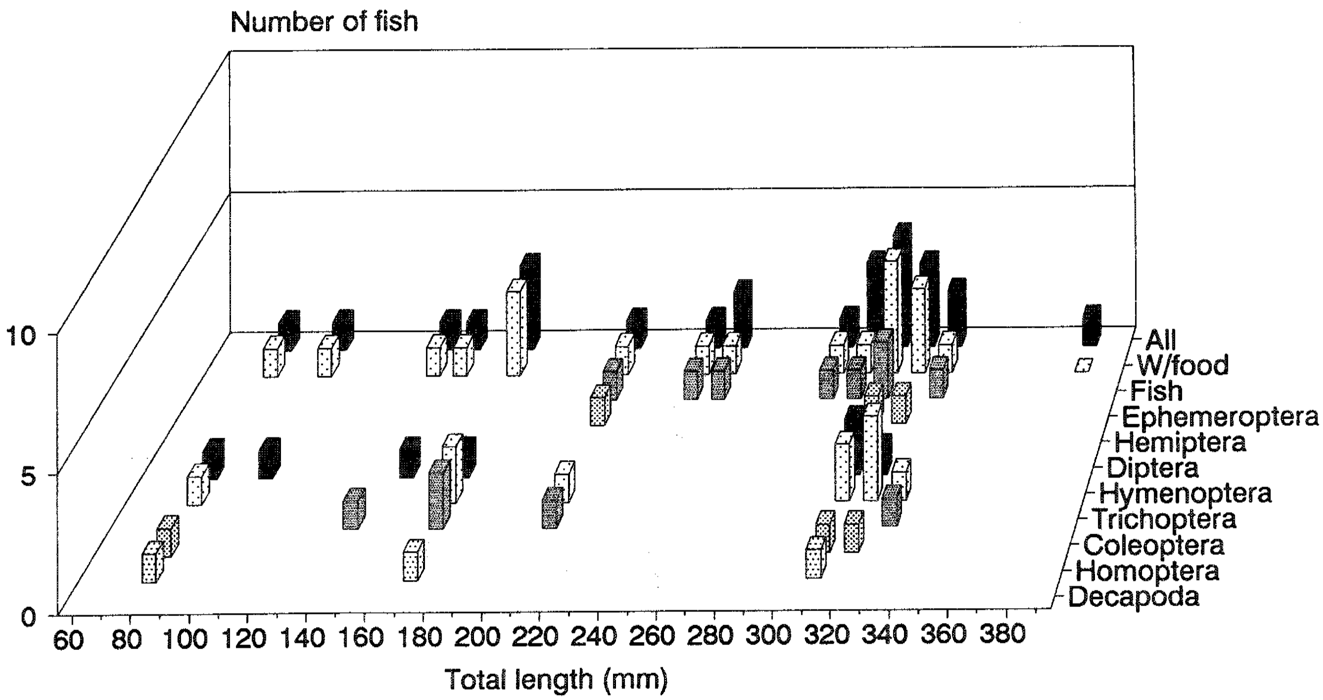


Figure 18. Food items contained in stomachs of smallmouth bass collected in 1988 (n=20) and 1989 (n=52) by percent frequency of occurrence, percent by number, Coefficient of Importance (C.I.) and Percent by volume, Dworshak Reservoir, Idaho.



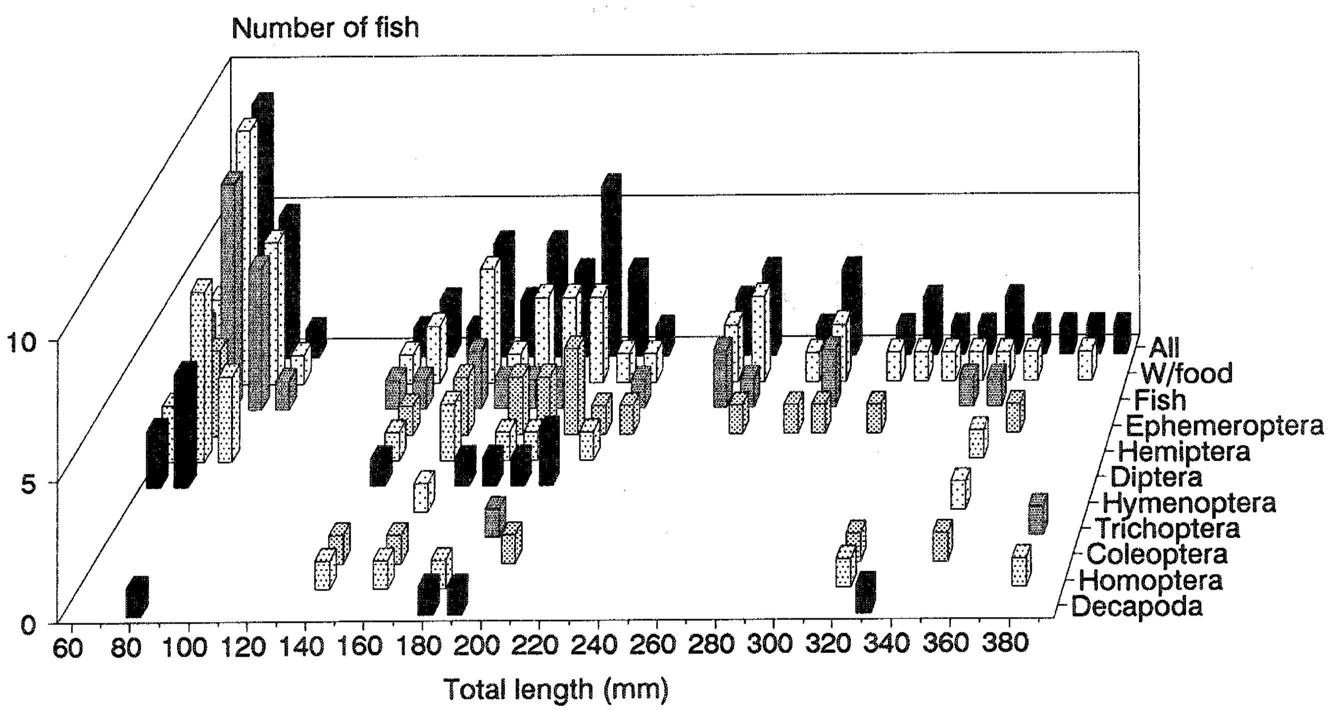
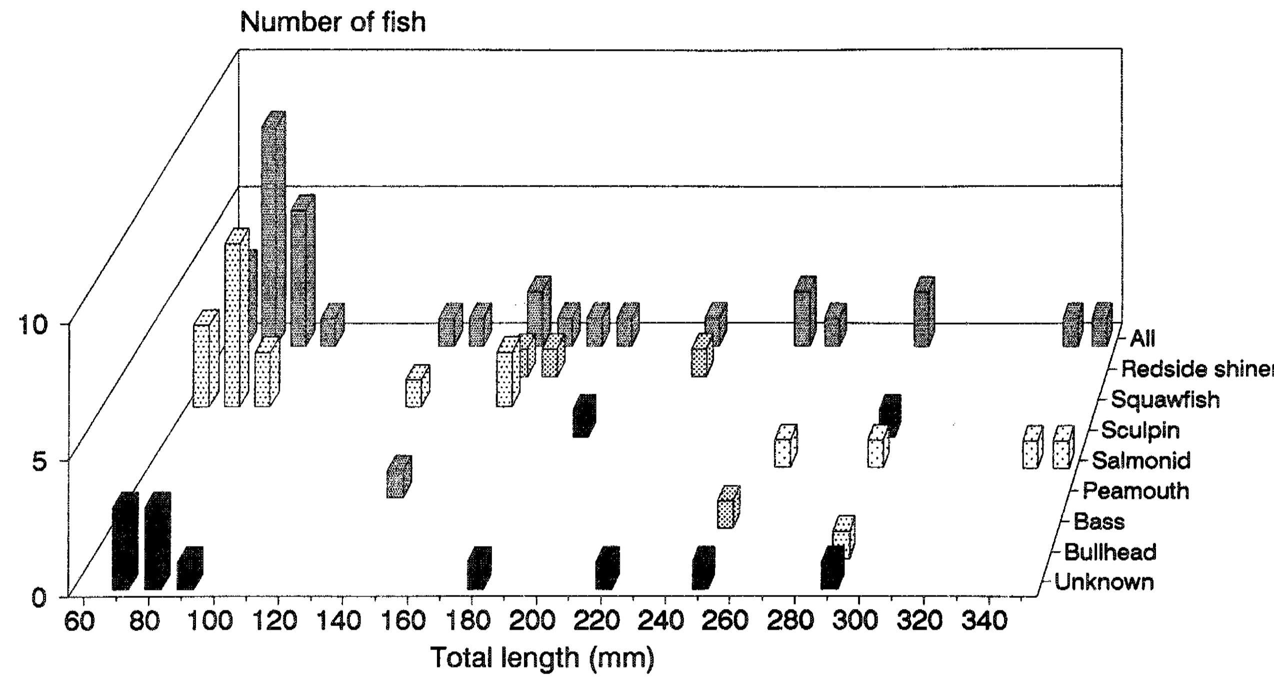


Figure 19. Length frequencies of smallmouth bass analyzed for food contents in 1988 (n=25) and 1989 (n=65) and number of fish per 10 mm size group containing the predominant food items as determined by the Coefficient of Importance (C.I.) and percent composition by volume, Dworshak Reservoir, Idaho.



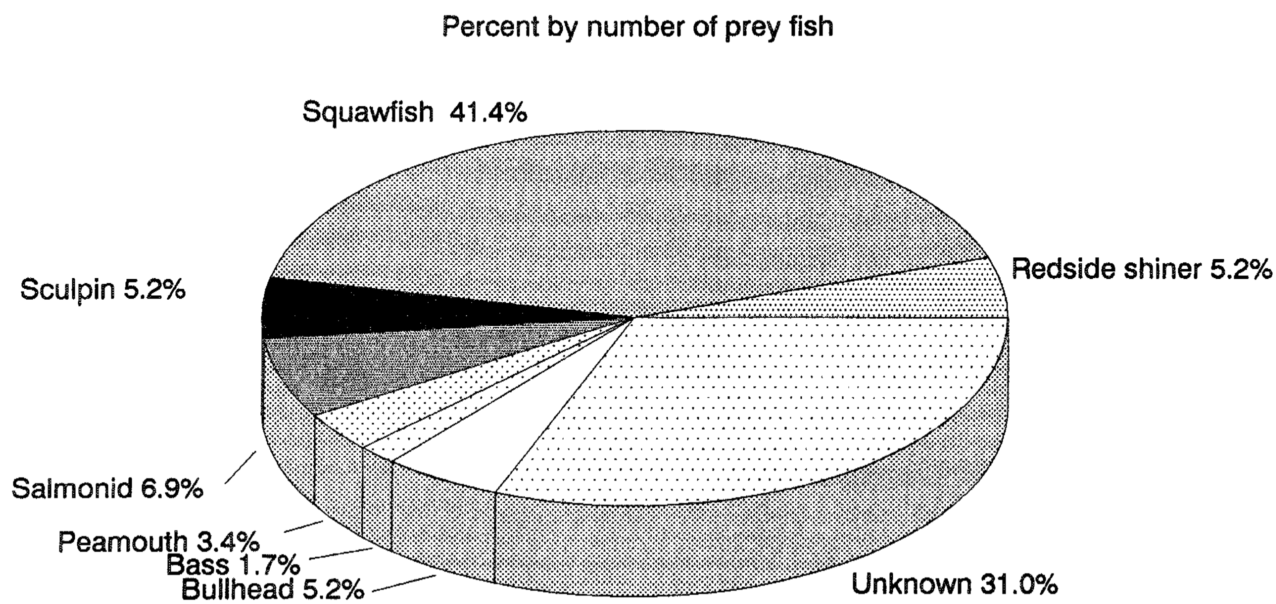


Figure 20. Length frequencies of smallmouth bass with ingested fish in 1989 (n=32), the number of bass per 10 mm size group containing the various prey species and the percent composition by number of prey species ingested by all size groups, Dworshak Reservoir, Idaho.

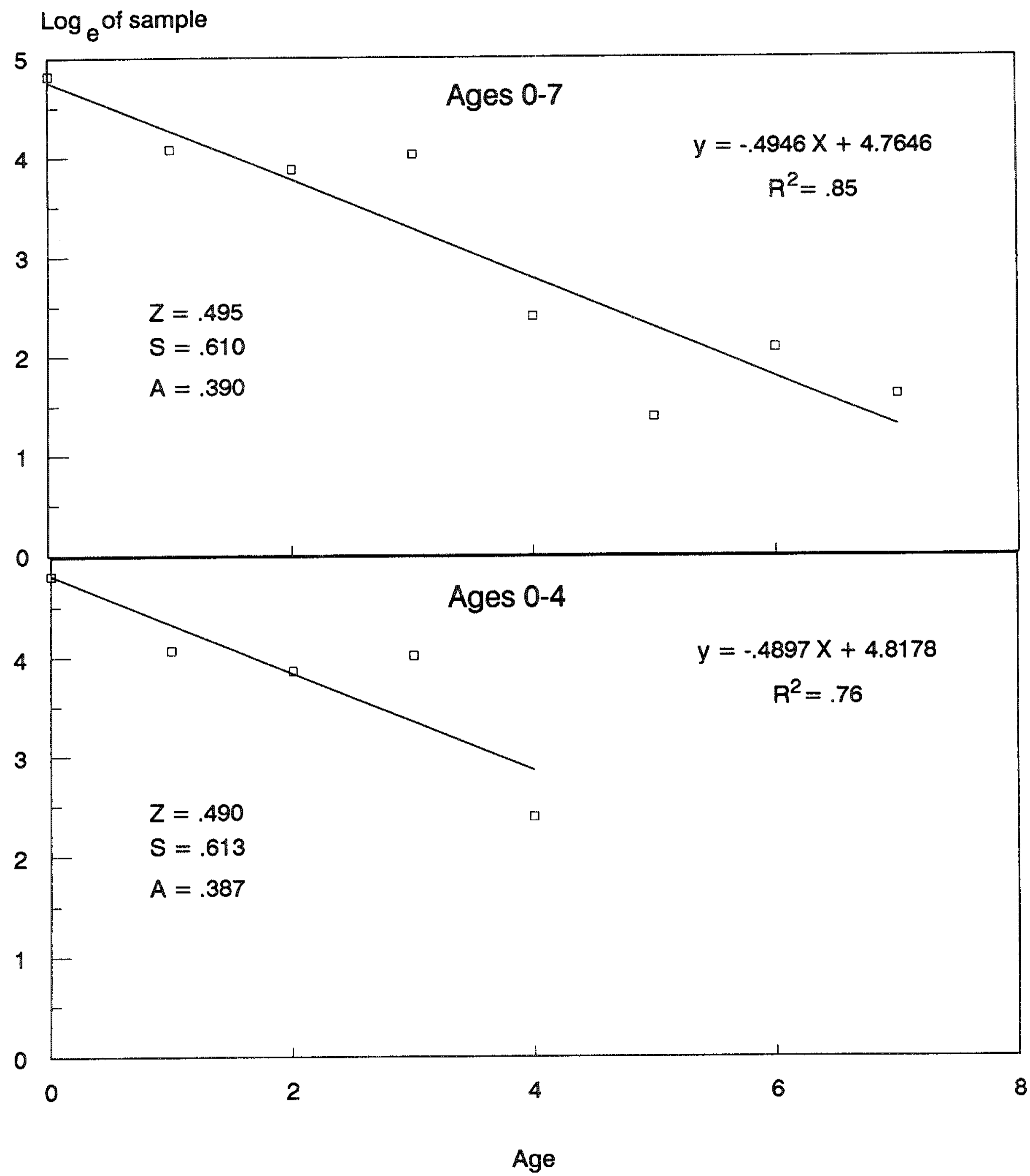


Figure 21. Catch curves, instantaneous mortalities (Z), survival rates (S) and total actual mortalities (A) for ages 0-7 and 0-4, as estimated from 242 smallmouth bass collected by electrofishing during 1989, Dworshak Reservoir, Idaho.

≥280 mm, for a PSD of 23.1 (Figure 22).

Relative Weight - Mean relative weight values per size group ranged from 88.0 for bass 101-200 mm to 95.8 for bass ≤100 mm (Figure 23). Smallmouth bass from 101-300 mm exhibited the lowest relative weights, which may be indicative of greater competition for food within these size groups.

Smallmouth Bass Equilibrium Yield Model

The model estimated a 77% increase in the total number of smallmouth bass harvested with a 254 mm minimum length limit, as compared to the existing 305 mm limit (Figure 24)(Table 9). The 254 mm limit would also increase yield (harvest weight) by 24%. The estimated mean length of fish harvested would be reduced from 338 mm to 296 mm. The decrease in length of fish harvested is largely influenced by the additional entry of the smaller age 4 fish. There would be an estimated 17% decrease in the number of age 5-9+ fish harvested.

Limnology

Unfiltered total phosphorous as P at station RK5 was quantified as "less than 50 micro g/L" from August 1987 when testing began to September 1989 when this method of analysis was completed (Appendix F). More sensitive analysis revealed total phosphorous level ranged from 4 micro g/L to 20 micro g/L and reached its highest values during December and peaked again during spring runoff. Lowest values were recorded during summer stratification and during mid-winter. Mean total phosphorus during 1990 was 9 micro g/L (Appendix F).

A similar though elevated pattern of total unfiltered phosphorous was observed in the Elk Creek Arm at EK6. High values of 17 to 24 micro g/L were found during spring runoff. Phosphorus dropped to 6 micro g/L during summer stratification. Mean total phosphorous for 1990 was 12 micro g/L (Appendix F).

Dissolved total phosphorous as P (filtered samples) ranged from 2 micro g/L to 14 micro g/L at station RK5 and averaged 5 micro g/L during 1990. Dissolved total phosphorous at EK6 ranged from 2 to 15 micro g/L and averaged 7 micro g/L during 1990 (Appendix F).

Dissolved ortho-phosphate as P (samples filtered in the field or by the lab), ranged from below detection limits to 7 micro g/L. Modal value of ortho-phosphate was 1 micro g/L at both RK5 and EC6 (modal values were used because of the difficulties with averaging "less than 1 micro g/L" amounts) (Appendix F).

Near-shore bottom temperatures at 1.5-2.5 m depth recorded at three locations (Merry's Bay, an Elk Creek tributary at river km 1.1 and Cold Creek) showed similar warming trends from April through July (Figure 25). Mean daily temperatures gradually increased from near 5 C in early April to 25 C towards the end of July (Figure 25). Water temperatures warmed to 15 C near the first of June. Temperatures began decreasing during the last week in August, and were near 18 C by the end of September (Figure 26). Maximum temperatures recorded were 27.9 C at Merry's Bay (.9 m depth on August 20), 28.1 C at the Elk Creek tributary (.5 m depth on August 22) and 26.5 C at Cold Creek (1.7 m depth on July 15 and 2.0 m on August 5).

An inverse relationship among depth and temperature was pronounced from mid-April until the pool stabilized during the last week in June (Figure 26). From May 14-30 at Merry's Bay, for one example, rising

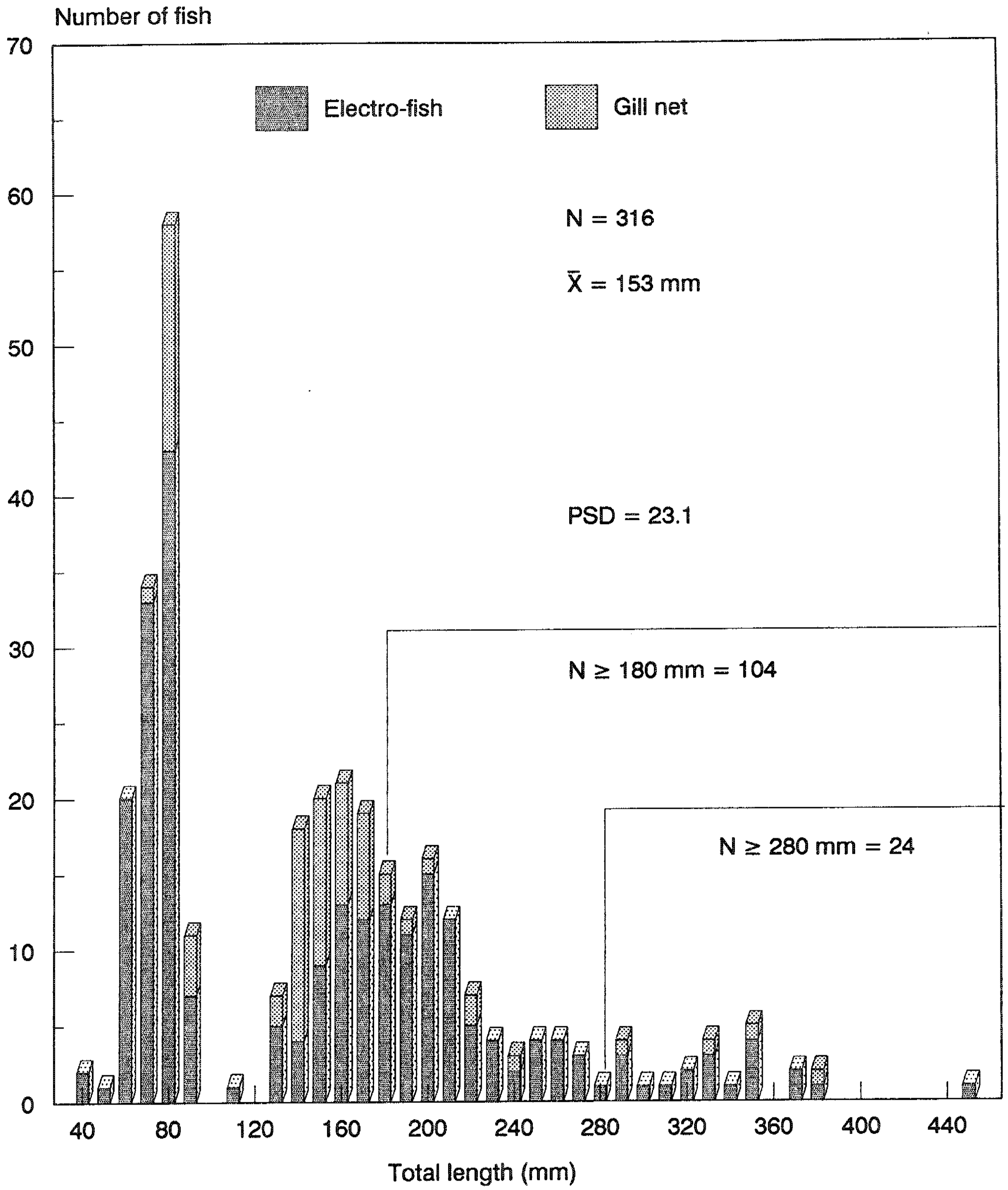


Figure 22. Length frequency, mean length (n=316) and proportional stock density (PSD)(n=104) for smallmouth bass, 1989, Dworshak Reservoir, Idaho.

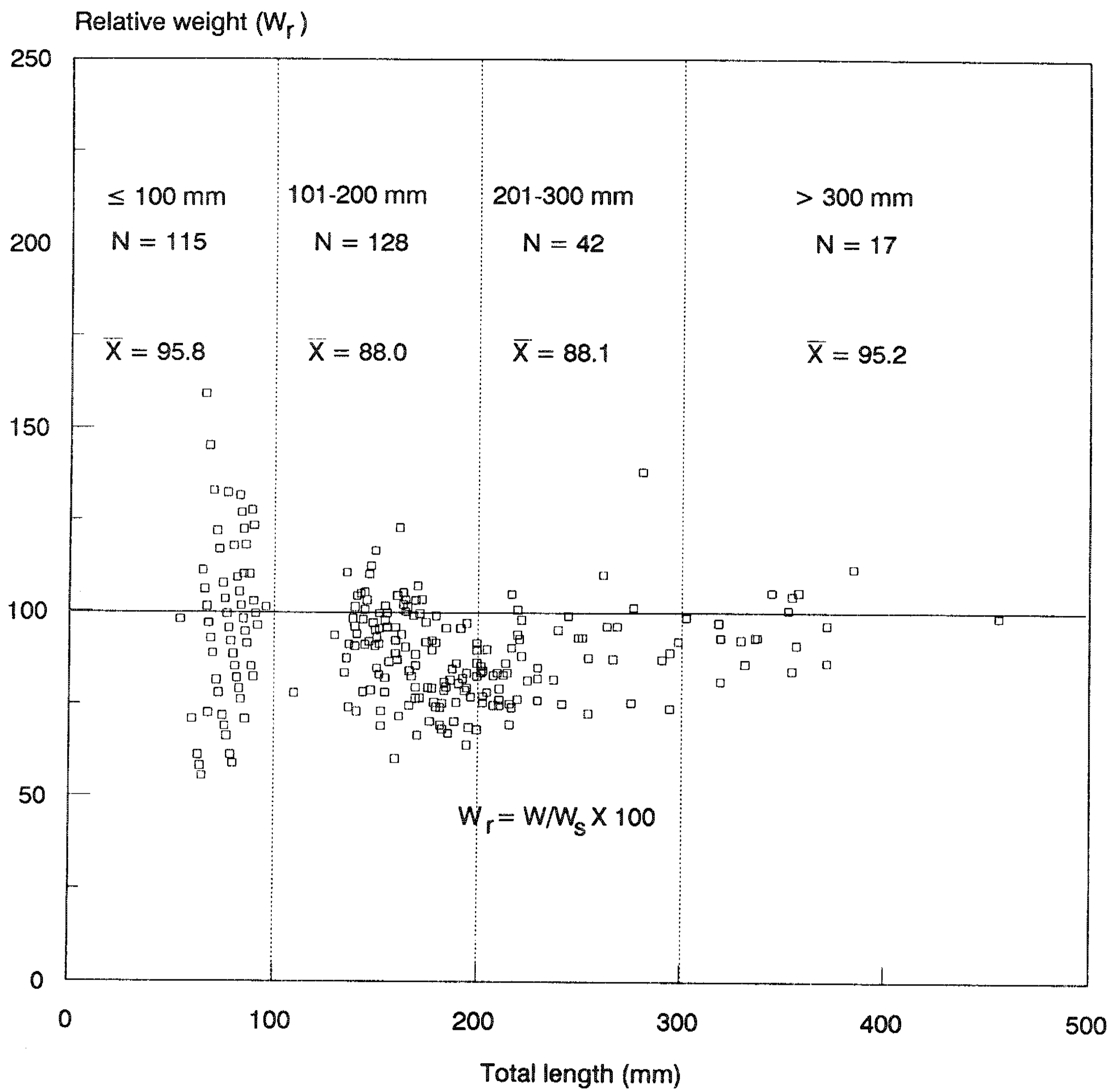


Figure 23. Mean relative weight (W_r) values for four size classes of smallmouth bass collected in 1989, Dworshak Reservoir, Idaho.

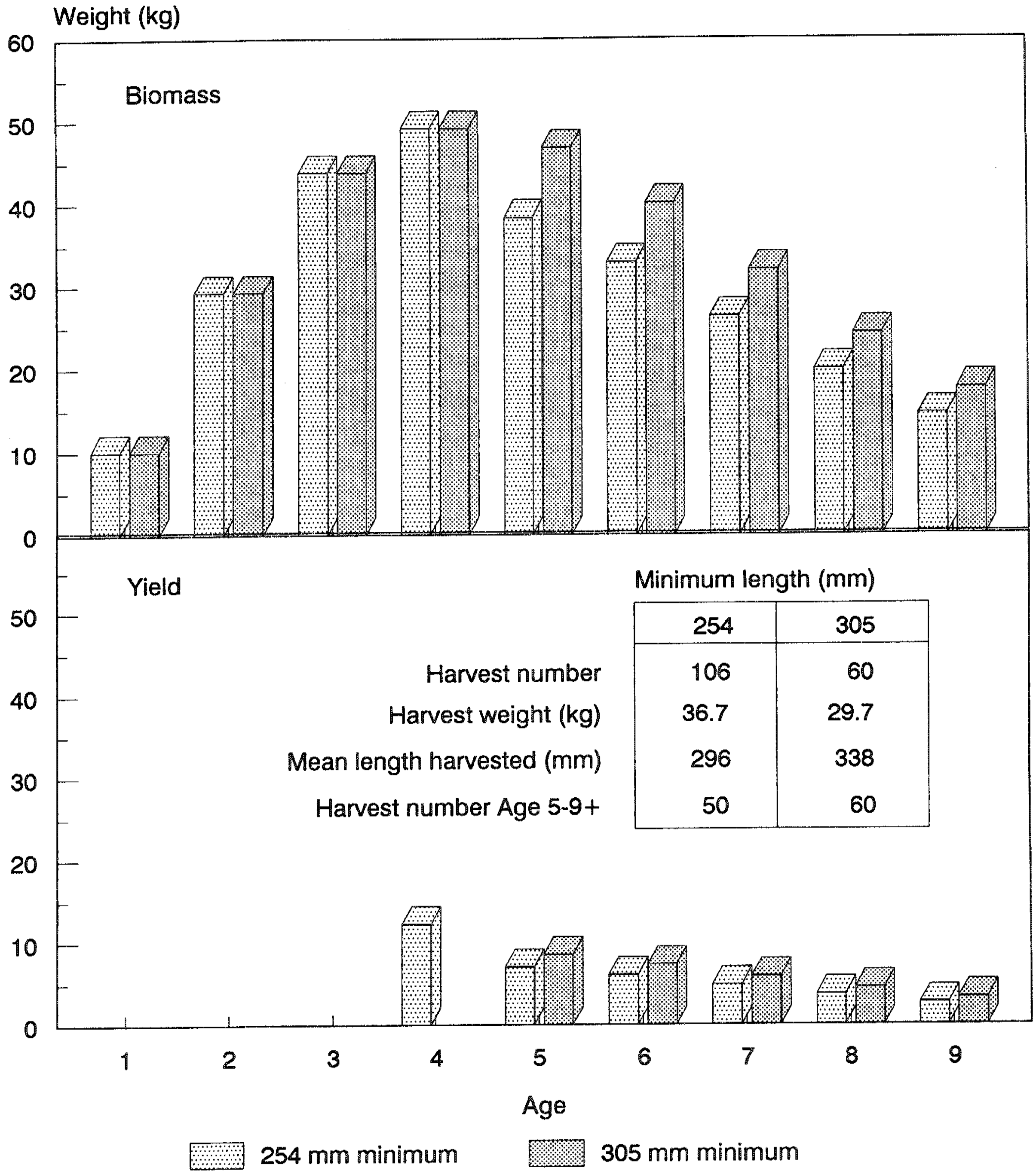


Figure 24. Initial biomass at age and harvested weight, number and length for 254 mm and 305 mm (existing) minimum size limits for Dworshak Reservoir Smallmouth bass as estimated through application of a 1,000 recruit equilibrium yield model (Ricker 1975).

Table 9. Equilibrium yield models representing minimum legal size limits for smallmouth bass of 254 mm (age 4, option a.) and 305 mm (age 5, option b.), Dworshak Reservoir, Idaho.

Option	Age	Average Weight (kg)	Initial Population	M	F	Z	S	Total Deaths	Catch	Yield (kg)
a.	1	.010	1000	.495	0	.495	.610	390	0	0.0
	2	.048	610	.495	0	.495	.610	238	0	0.0
	3	.118	372	.495	0	.495	.610	145	0	0.0
	4	.217	227	.346	0.346	.692	.501	113	57	12.3
	5	.339	113	.261	0.234	.495	.610	44	21	7.1
	6	.477	69	.261	0.234	.495	.610	27	13	6.1
	7	.624	42	.261	0.234	.495	.610	16	8	4.9
	8	.775	26	.261	0.234	.495	.610	10	5	3.7
	9+	.925	16	.261	0.234	.495	.610	6	3	2.7
			10							
	Totals							990	106	36.7
b.										
	1	0.010	1000	.495	0	.495	.610	390	0	0.0
	2	0.048	610	.495	0	.495	.610	238	0	0.0
	3	0.118	372	.495	0	.495	.610	145	0	0.0
	4	0.217	227	.495	0	.495	.610	88	0	0.0
	5	0.339	138	.261	0.234	.495	.610	54	25	8.6
	6	0.477	84	.261	0.234	.495	.610	33	16	7.4
	7	0.624	51	.261	0.234	.495	.610	20	9	5.9
	8	0.775	31	.261	0.234	.495	.610	12	6	4.5
	9+	0.925	19	.261	0.234	.495	.610	7	4	3.3
			12							
	Totals							988	60	29.7

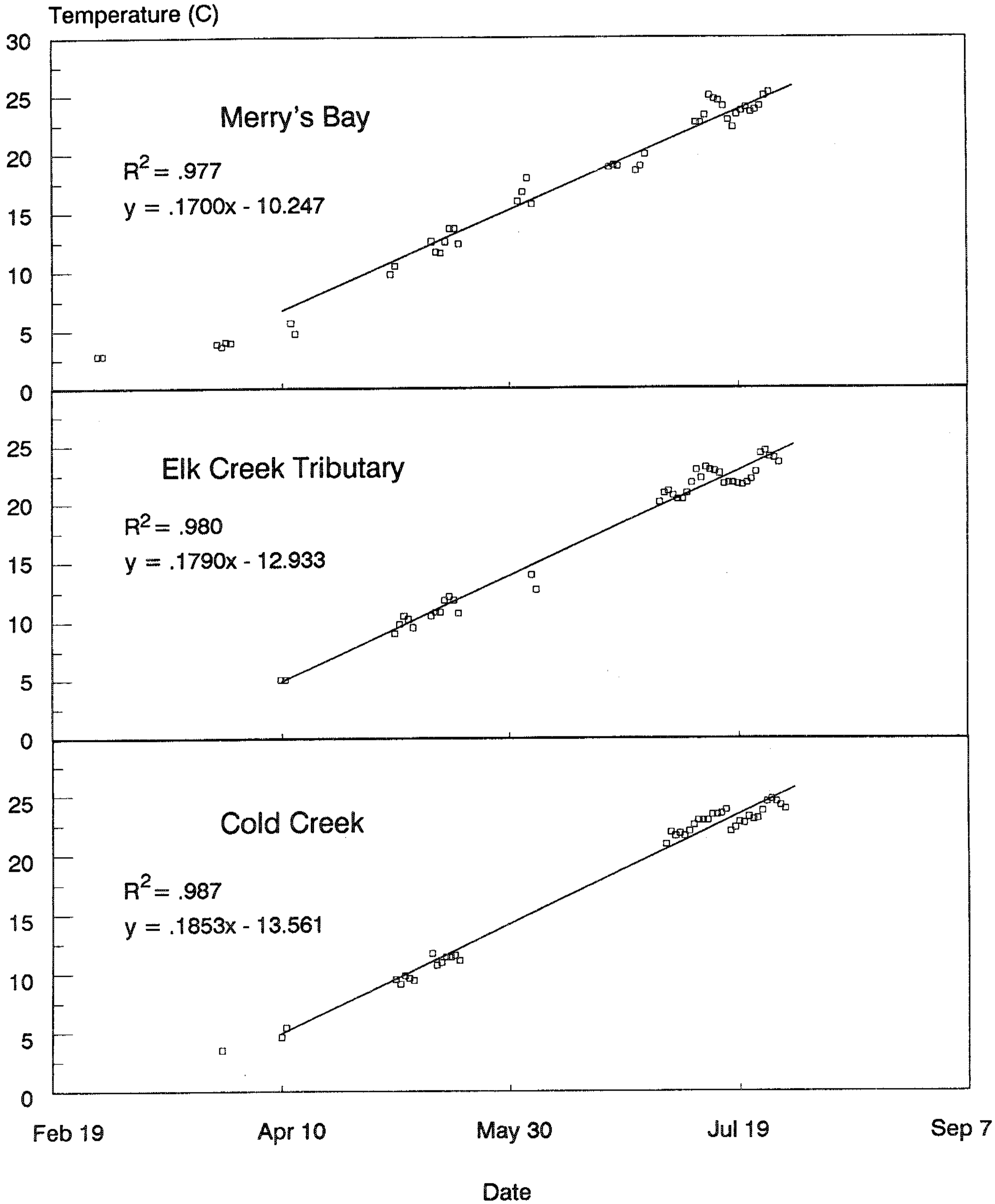


Figure 25. Shallow water (1.5-2.5 m) warming trends at three locations during spring 1991, Dworshak Reservoir, Idaho.

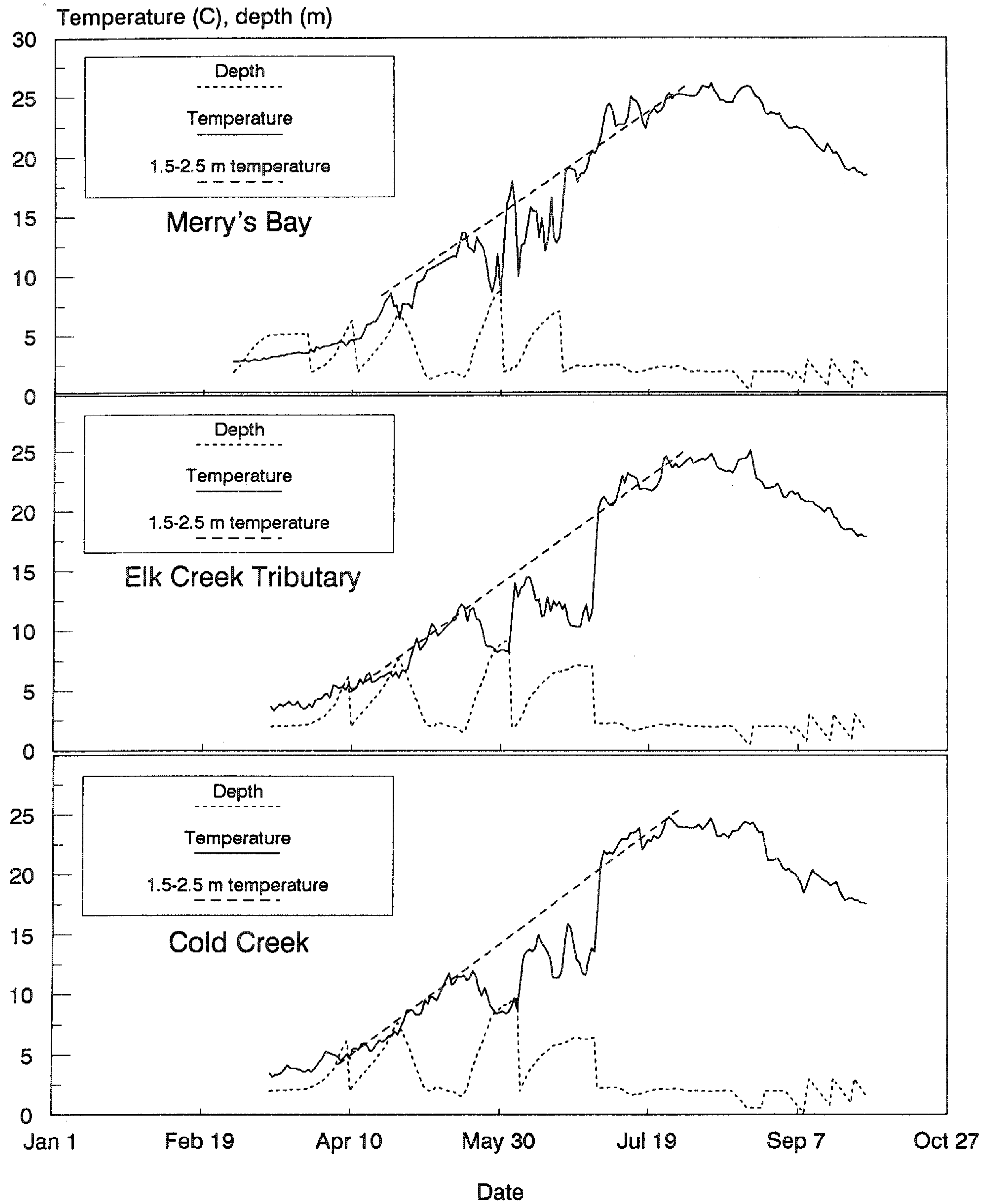


Figure 26. Nearshore bottom temperatures in relation to fluctuating depths at three locations during 1991, Dworshak Reservoir, Idaho.

pool levels increased the near-shore depth of the stationary temperature sensor from 2.0 m to 8.8 m (+6.8 m), and correspondingly decreased mean daily temperatures from 11.7 to 8.4 C. This temperature depression of .19 C/day occurred when the shallow water (1.5-2.5 m) near-shore habitat was continually warming at the rate of about .16 C/day. Had the pool level remained stable during this interval, the stationary near-shore location would have warmed to near 15 C, rather than decreased. As another example, from June 4-25 at the Elk Creek tributary site, a 5.1 m increase in depth at the sensor (2.0 to 7.1 m) resulted in a 3.7 C (14.0-10.3) temperature reduction. With stable pool conditions during this interval we would have expected warming at the site of about 4.5 C (14-18.5).

Creel Survey

Anglers fished an estimated 149,592 hours during 1990 to catch 94,757 kokanee, 19,673 smallmouth bass, 12,981 rainbow trout, 157 cutthroat trout and 151 bull trout. Other fish caught, including mountain whitefish, black crappie, brown bullhead, northern squawfish and suckers, totalled 282 (Figures 27, 28, and 29). The overall annual catch rate was .86 fish/h.

Kokanee anglers fished 113,297 hours to harvest 94,757 kokanee at 0.84 fish/h during 1990. Harvest was 7,249 kokanee in March and 2,740 in April. Levels increased to 27,616 in May, 30,997 in June and 23,292 in July, then declined to 2,543 in August. Harvest was below 130 kokanee/month the remainder of the year (Figure 27)(Appendix G). Creeled kokanee averaged 268 mm and 159 g (Figure 27). Yield was 2.3 kg/hectare including incidental harvest of kokanee by anglers seeking other species.

Kokanee angling comprised 80.0% of the total boat angling effort of 143,423. Boat anglers caught 29,314 fish other than kokanee at .20 fish/h (Figures 28 and 29). The non-kokanee catch by boat anglers was primarily smallmouth bass (17,924) and rainbow trout (11,001)(Figure 29). The rainbow trout catch by boat anglers includes an estimated 4,890 caught and released hatchery rainbow trout that were stocked in May as subcatchables (Figure 30).

Bank anglers fished 6,169 hours during 1990 to catch 3,929 fish at .64 fish/h (Figure 28). Catch rates equalled or exceeded 1 fish/h during January, July, September, November and December. The catch was 50.4% (1,980) rainbow trout and 44.5% smallmouth bass (1,749)(Figure 29).

During 1991, monthly creel surveys were limited to January and February. Boat anglers fished 31 hours during January to catch 8 rainbow trout at .26 fish/h. During this time bank anglers expended 320 hours to catch 230 rainbow trout at .72 fish/h. During February, boat anglers fished 697 hours to catch 67 rainbow trout (.10 fish/h) and 16 kokanee (.02 fish/h). February bank anglers caught 210 rainbow trout during 584 hours of fishing for a catch rate of .36 fish/h. The fishery was also sampled during mid-July in conjunction with our trawling effort. Angler interviews covered 284 h of fishing time, harvest was 149 kokanee at a catch rate of 0.52 fish/hour.

Three years of creel data from 1988 through 1990 show catch rates for species other than kokanee to be highest during late autumn and winter. (Figures 28, 31 and 32). The non-kokanee catch by both boat and bank anglers is consistently dominated by rainbow trout and smallmouth bass (Figure 29).

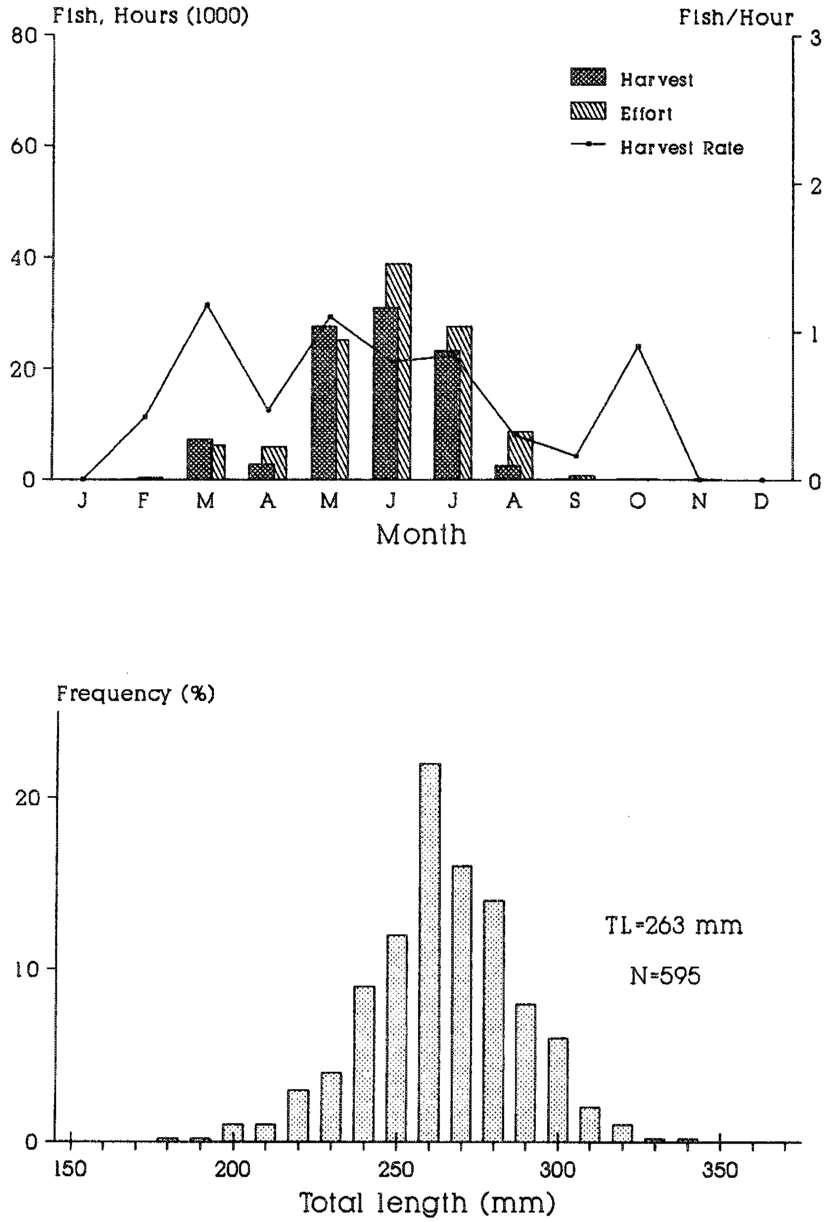


Figure 27. **Catch rate, effort and harvest by anglers fishing for kokanee on Dworshak Reservoir in 1990, and size of kokanee in the harvest.**

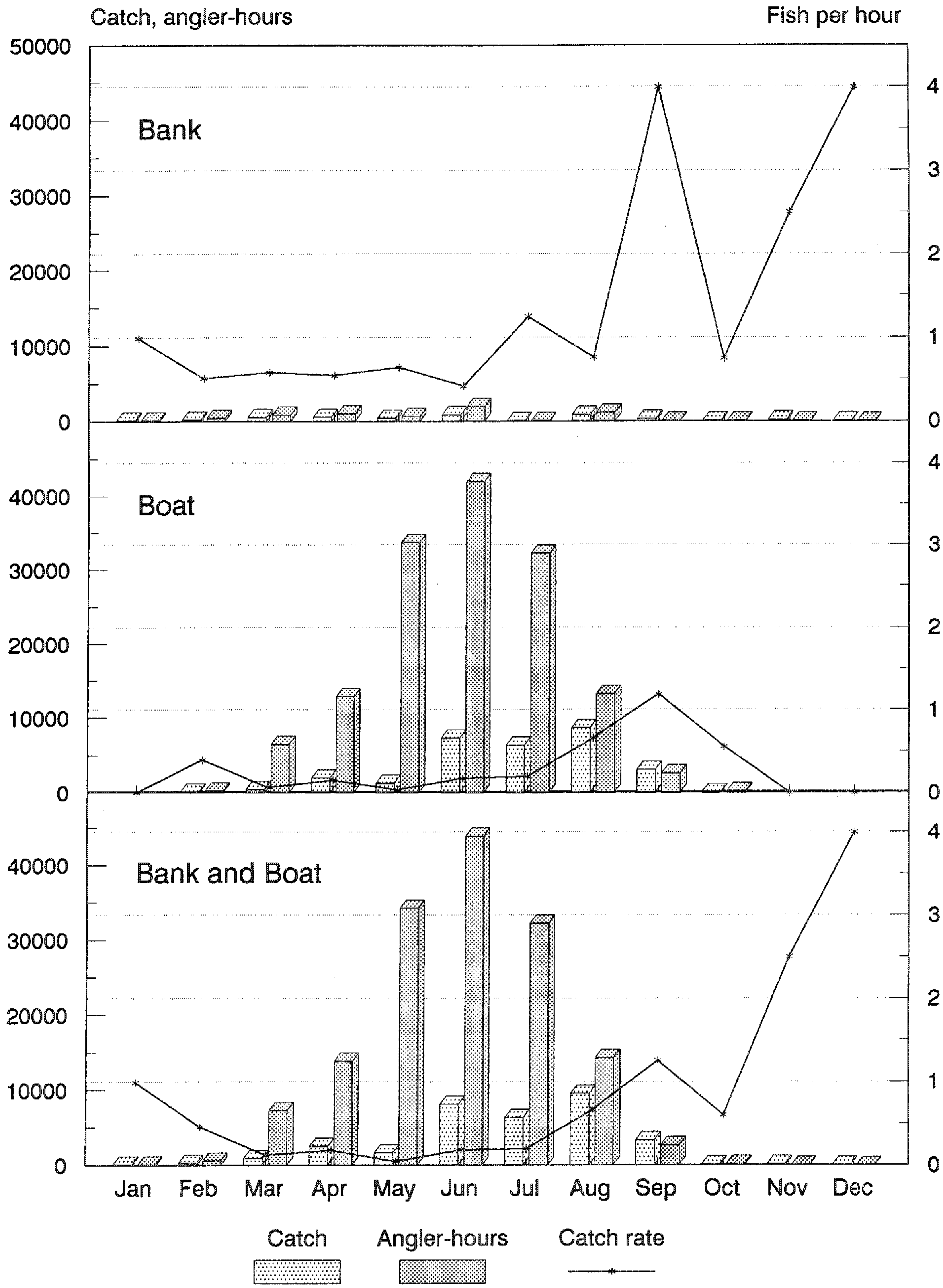


Figure 28. Monthly bank and boat angling catch effort (angler-hours) and catch rates for species excluding kokanee during 1990, Dworshak Reservoir, Idaho.

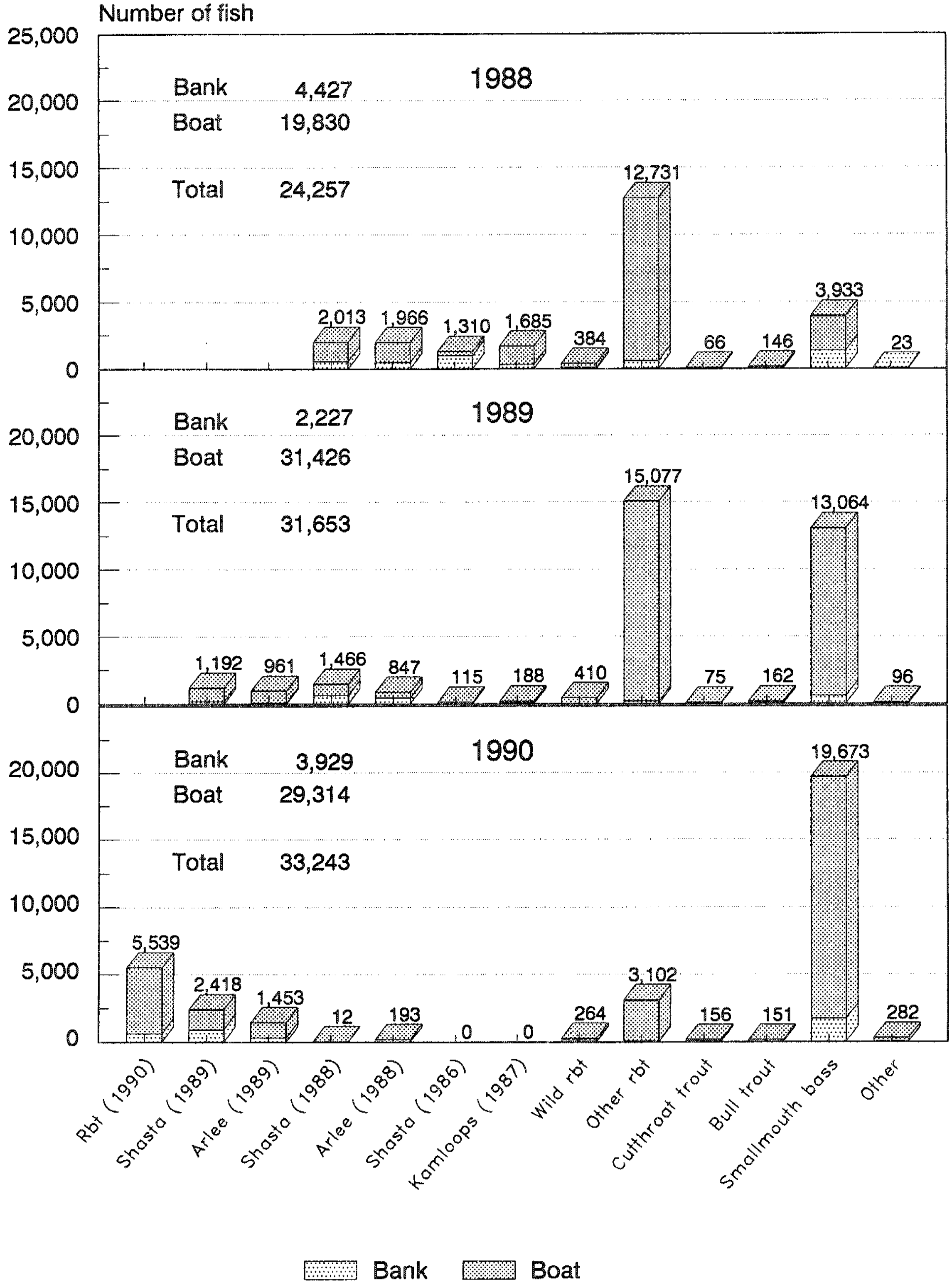


Figure 29. Non-kokanee catch composition by species and rainbow trout strain from 1988 through 1990, with rainbow trout release years in parentheses, Dworshak Reservoir, Idaho.

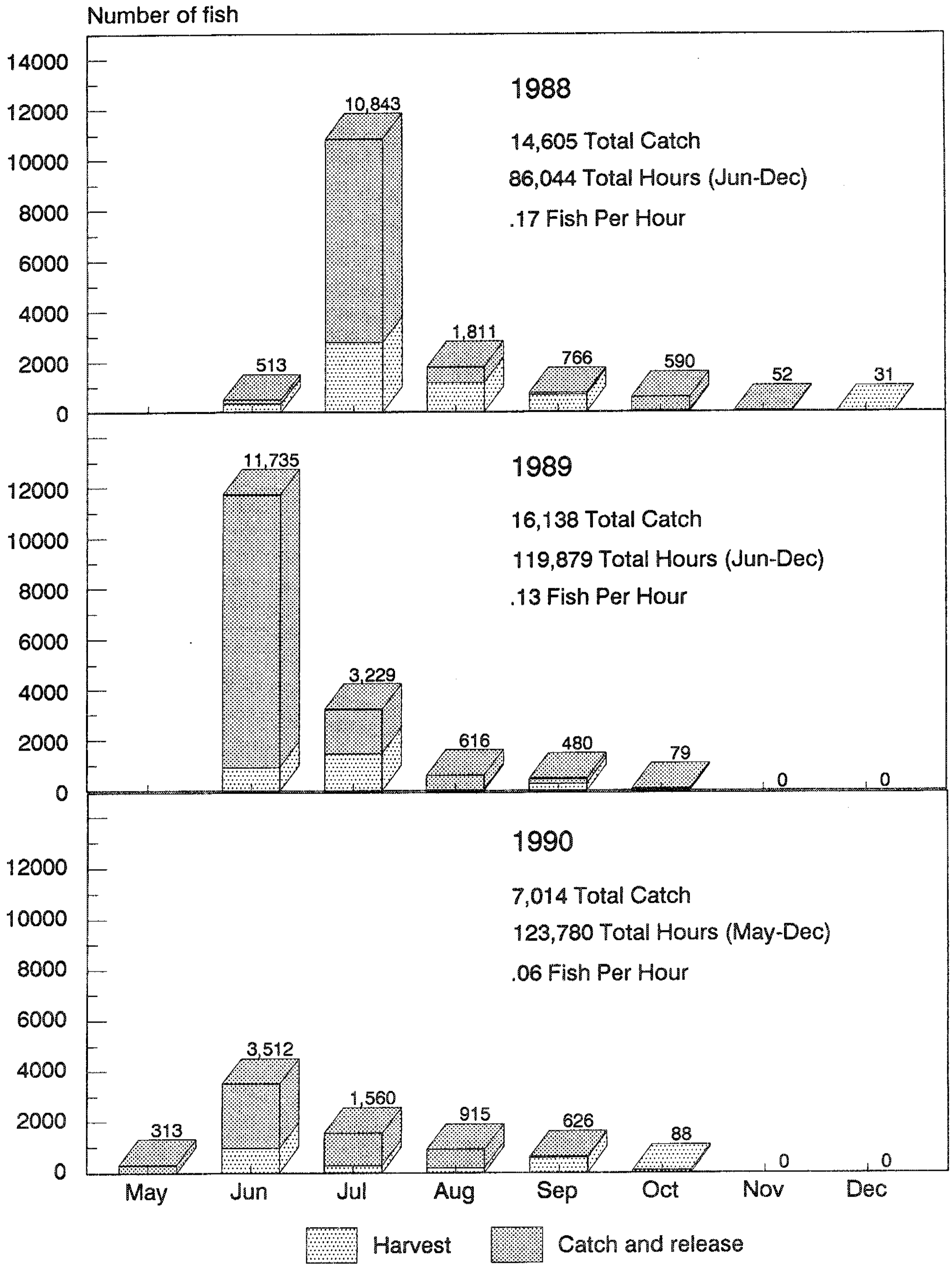


Figure 30. Boat angling harvest, catch and release, and catch rate for rainbow trout stocked as subcatchables during June 1988 (294,908 at 158 mm), June 1989 (245,380 at 157 mm) and May 1990 (222,026 at 130 mm), Dworshak Reservoir, Idaho.

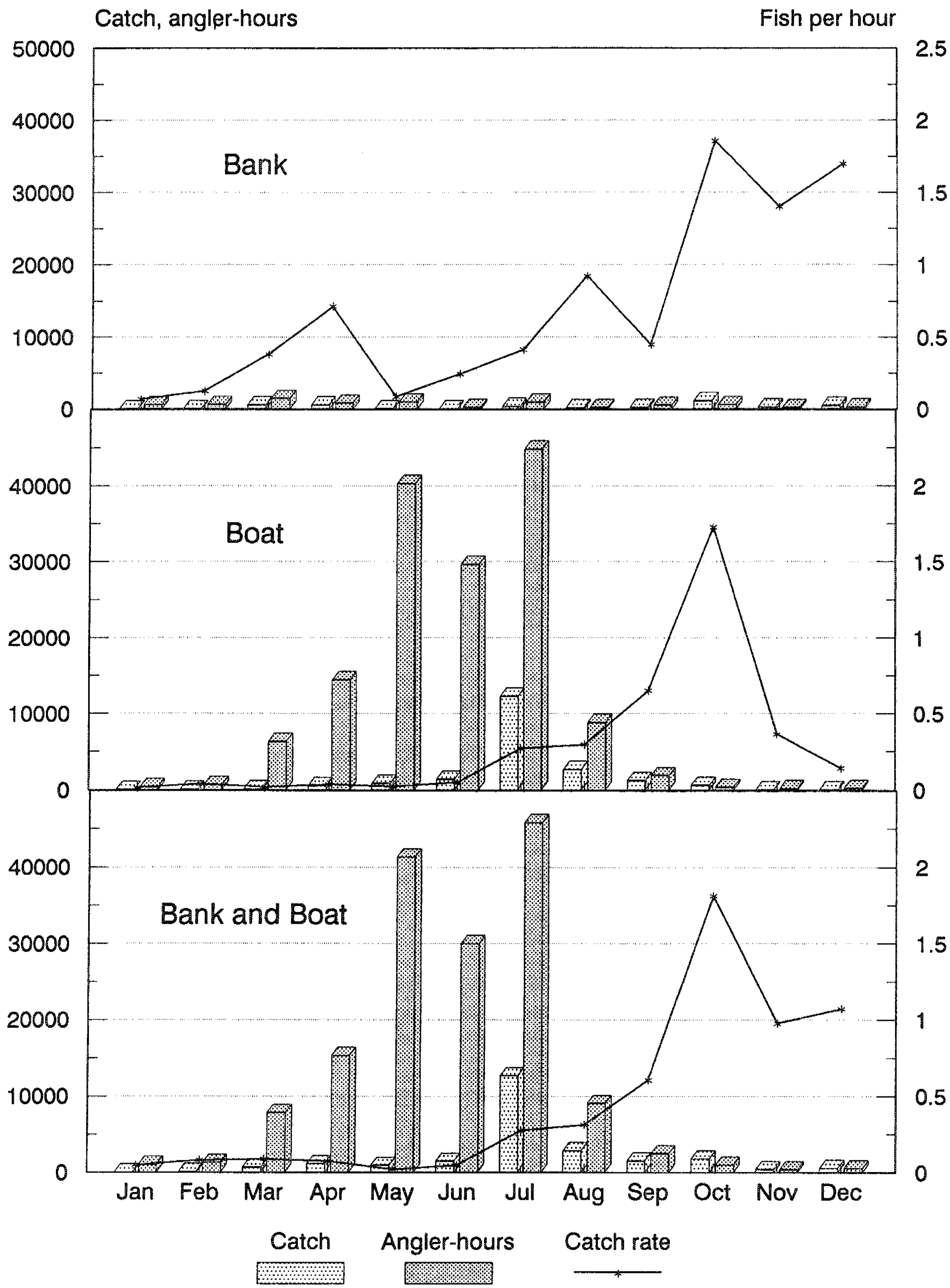


Figure 31. Monthly bank and boat angling catch, effort (angler-hours) and catch rates for species excluding kokanee during 1988, Dworshak Reservoir, Idaho.

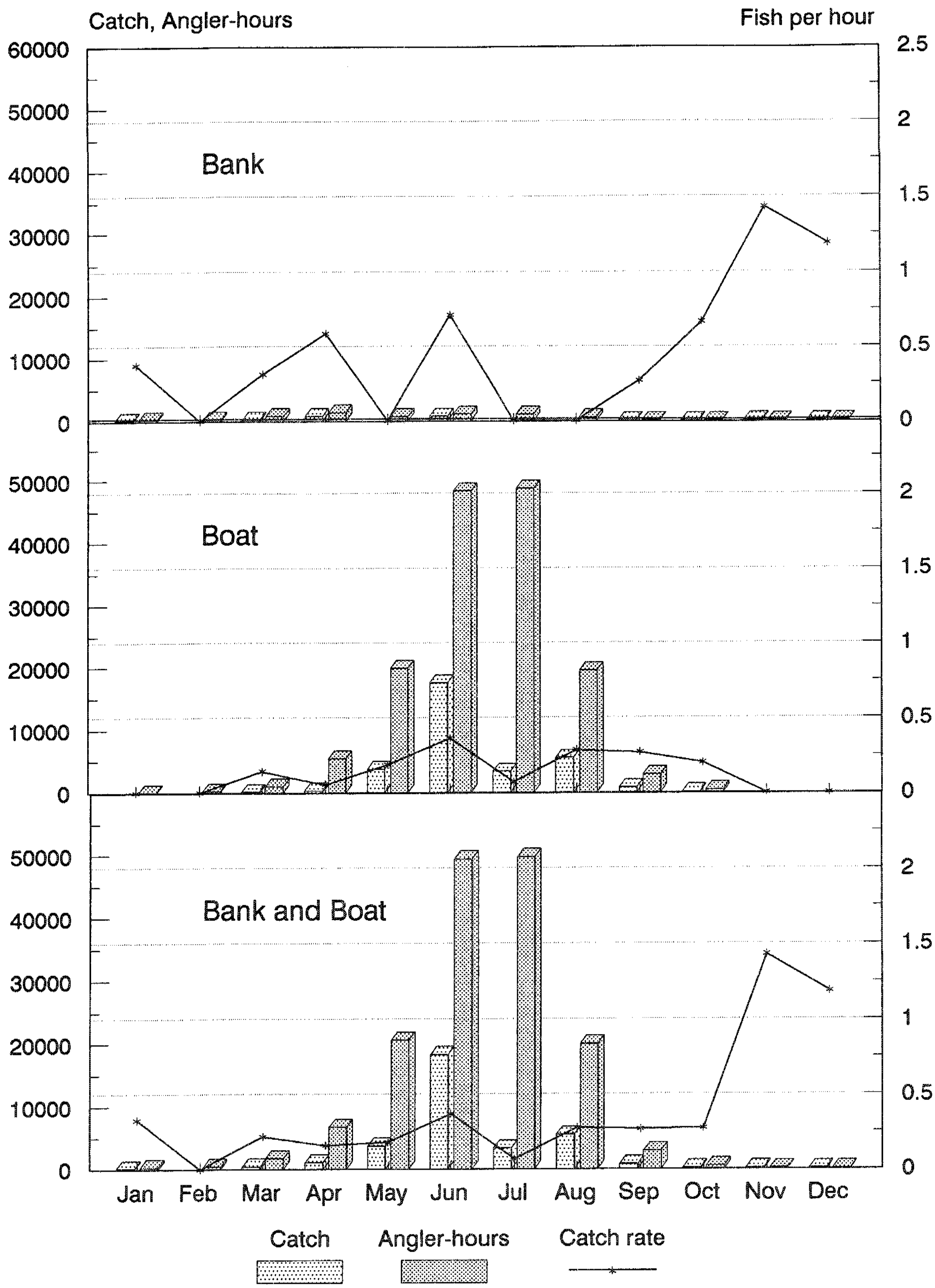


Figure 32. Monthly bank and boat angling catch, effort (angler-hours) and catch rates for species excluding kokanee during 1989, Dworshak Reservoir, Idaho.

Recently stocked rainbow trout subcatchables caught incidentally by kokanee anglers are typically released (Figure 30). The post-release catch of subcatchable rainbow trout stocked in May 1990 at 130 mm in length was .06 fish/h. This was less than one-half the catch rates observed during 1988 (.17 fish/h) and 1989 (.13 fish/h), when rainbow trout were stocked in June at 158 mm and 157 mm, respectively.

An estimated 92.8% (18,249) of the smallmouth bass caught during 1990 were released, with an estimated harvest of 1,424. Anglers fished 24,383 hours specifically for smallmouth bass during 1990, representing 16.3% of the total angling effort. Similarly high release percentages of 88.6% (3,483) and 93.2% (12,169) were observed during 1988 and 1989, respectively. The respective annual harvests of smallmouth bass for 1988 and 1989 were 450 and 895 (Statler 1989, 1990).

Harvest of kokanee has increased since the early 1970's, and rainbow trout harvest has declined (Figure 33). Although the species composition of the catch has changed, overall catch, effort and catch rates are currently similar to the early 1970's fishery.

Additional creel statistics were presented in previous annual reports by Maiolie (1988), Mauser et al. (1989, 1990) and Statler (1988, 1989, 1990).

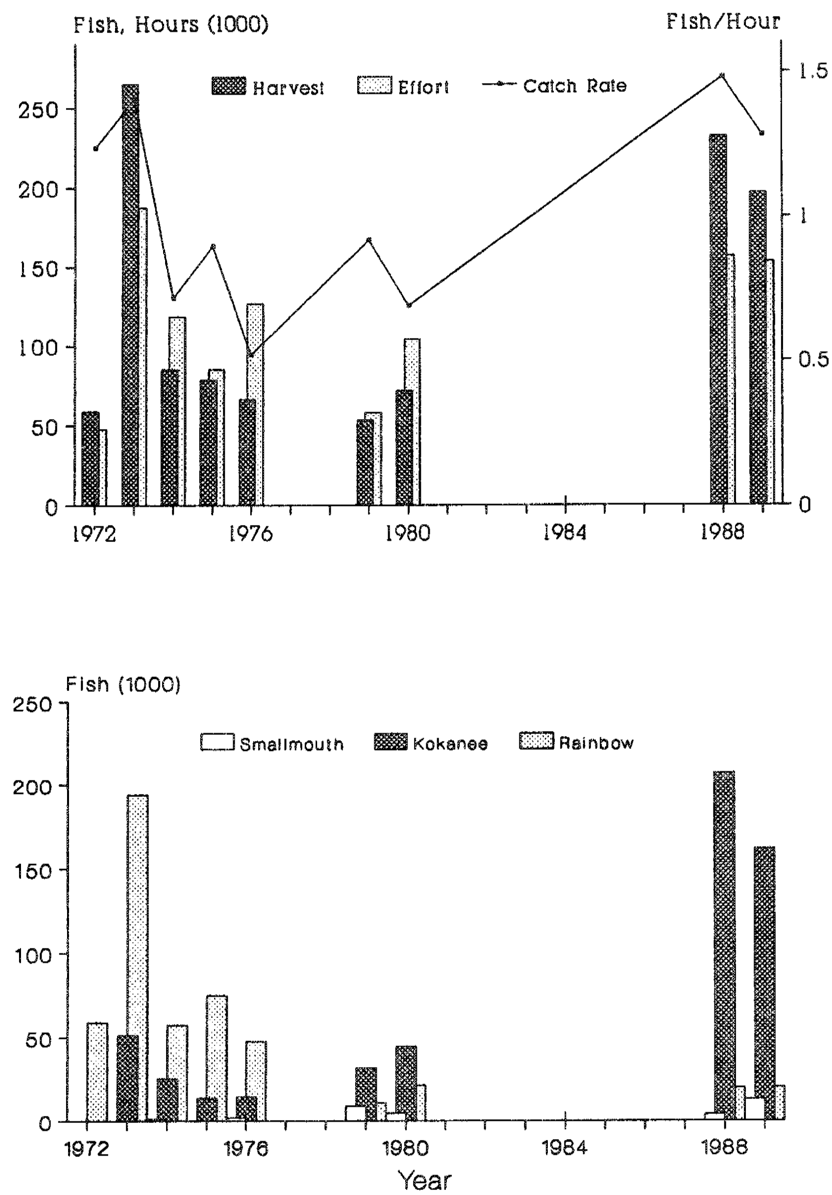


Figure 33. Catch, effort and catch rate for all fish species, and harvest levels for kokanee, rainbow trout and smallmouth bass from Dworshak Reservoir, 1972-1990.

DISCUSSION

Kokanee

Abundance

Tributaries to Dworshak Reservoir were once high quality spawning grounds for anadromous fish. As such, they were also expected to provide many miles of prime spawning areas for kokanee. Our best estimates of age 0 kokanee abundance were those made in September of 1989 and 1990 since young-of-the-year fish would be more fully recruited to our trawling gear later in the year. Age 0 kokanee density during these years was estimated at 120 and 181 kokanee/hectare. Spirit Lake, one of Idaho's prominent kokanee fisheries, produced a mean of 145 age 0 kokanee/hectare (mean of years 1985 to 1989), and Lake Pend Oreille produced 180 kokanee/hectare (mean of years 1986 to 1990 including supplemental hatchery production). Survival rate from potential egg deposition to fall fry averaged 1.95% (Table 10). This was similar to the 2.58% average for Coeur d'Alene Lake (1980-1989)(Maiolie et al. 1991). Thus, production of kokanee fry into Dworshak Reservoir appeared to be similar to other major kokanee fisheries and spawning areas and spawning success were not thought to be limiting the population, nor was initial fry survival.

Dworshak Reservoir did, however, have wide shifts in the number of kokanee recruited to the fishery; from 32.4 kokanee/hectare in 1989 to 4.6 kokanee/hectare in 1991 (Table 3). This lower value was far below densities observed in other kokanee fisheries; Coeur d'Alene Lake - 47 to 262 kokanee/hectare, Lake Pend Oreille - 16 to 57 kokanee/hectare, and Spirit Lake - 84 to 272 kokanee/hectare (Rieman and Meyers 1990). The low densities of kokanee in 1991 did markedly affect the fishery. Rieman and Meyers (1990) documented that as kokanee density was reduced, they grew larger and were more vulnerable to angling gear. Thus, reduced densities provided larger fish with similar catch rates for the fishery. However this relationship was true only to a certain point, beyond which kokanee became so few that catch rates were reduced even though they were larger and more vulnerable to fishing gear. Dworshak Reservoir in 1991 appeared to have such low densities (4.6 fish/hectare) that catch rates (0.52 kokanee/hour) were about one third the catch rate that was documented in previous years (Mauser et al 1989, Mauser et al. 1990). Catch rates closely fit the relationship developed by Rieman and Meyers (1990) which indicated more kokanee in the population in 1991 would have improved catch rates (Figure 34). Also, anglers reported growing dissatisfaction with the fishery as kokanee abundance declined from 1988 to 1990 (Figure 35), even though these were relatively good years based on spawner counts (Table 6).

Survival Rates

Good abundance of fry resulting in low abundance of adults became quite apparent in survival rate estimates. Our calculated survival rates for kokanee from ages 0 to 1, 1 to 2, and 2 to 3, averaged 31%, 17%, and 20%, respectively (Table 5). Rieman and Meyers (1990) summarized survival rates of kokanee at 30 to 60% for age 0 to 1 (n=18), 90% for age 1 to 2 (n=28), and 57% for age 2 to 3 (n=27). These average survival rates were based on other Idaho lakes, some with established predator populations. Thus survival rates for kokanee in Dworshak Reservoir were far below other kokanee fisheries.

Mortality of kokanee from age 0 to 1 was due to natural factors and entrainment mortality. (Fishing mortality was insignificant since

Table 10. Potential egg deposition and survival rates of resulting fry in Dworshak Reservoir, Idaho.

	Estimates			
Year	Female spawning escapement (x 1,000)	Potential egg deposition (x1,000)[1]	Fall fry from previous years escapement (x 1,000)	Potential egg to fall fry survival (%)
1988	78	41,028	--	
1989	88	41,626	648	1.6
1990	--[2]	--	978	2.3
1991	13	7,514	132	--

[1] Calculated from the formula $Y=-947+5.26x$, where x=total length of females (mm) (B. Rieman, Personal communication, Idaho Department of Fish and Game, Eagle Fish Lab, Eagle, Idaho).

[2] September trawling too late in year to get a reliable estimate.

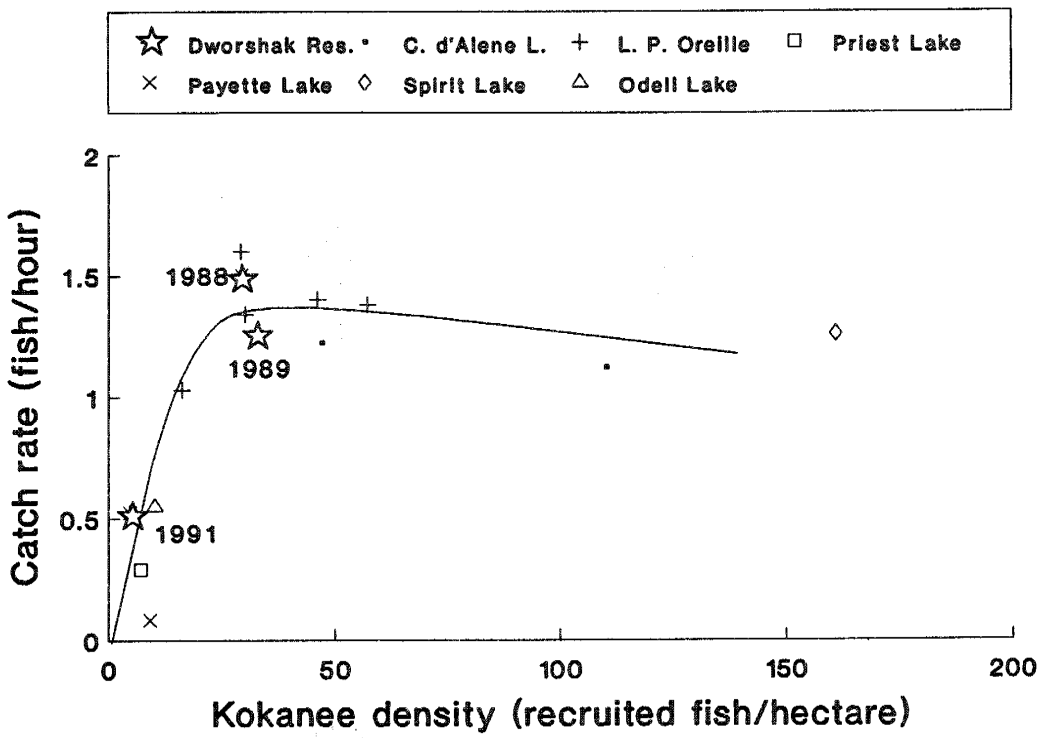


Figure 34. Relationship of the density of kokanee that are recruited to the fishery and the resulting catch rate of the kokanee fishery, (Rieman and Meyers 1990, with modifications).

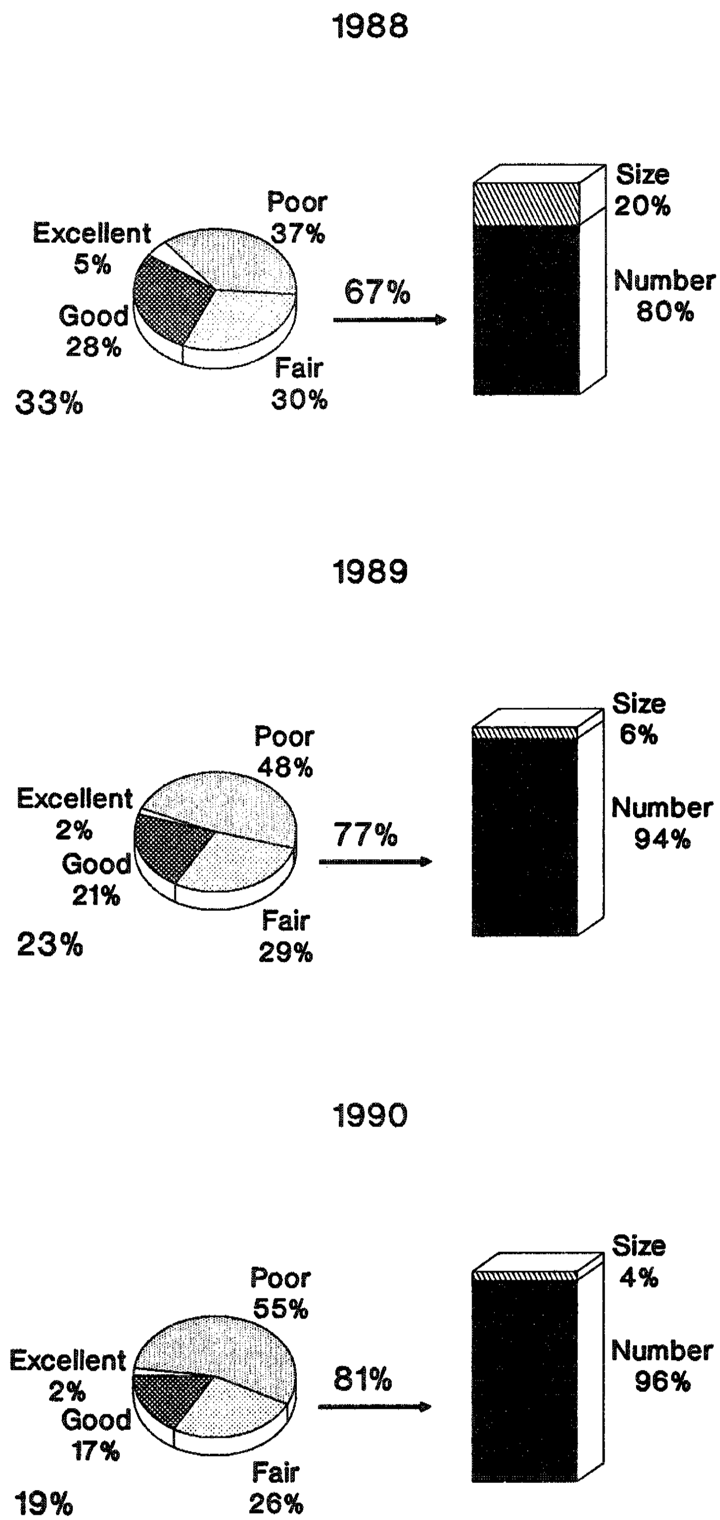


Figure 35. Results of angler survey regarding quality of kokanee fishing on day of contact on Dworshak Reservoir, Idaho, 1988-1990. Bar indicates why they thought fishing was poor or fair.

they had not yet recruited to the fishery.) If we assume natural mortality was 55% (the mean value from other Idaho Lakes (Rieman and Meyers 1990)), then entrainment mortality accounted for a relatively consistent 15% to 24% of the age 0-1 kokanee mortality. This equates to 83,000 to 235,000 kokanee annually (Table 11).

Mortality of kokanee from age 1 to 2 could be partitioned into natural, entrainment, and fishing mortalities. Only from July 1988 to July 1989 did we have creel surveys and an appropriately timed trawling effort to quantify the three components of mortality. During that time we estimated 501,000 age 1 kokanee were reduced to 175,000 age 2 kokanee by anglers harvesting 140,000 fish, natural mortality taking 50,000 fish and entrainment losses accounting for 136,000 fish (Table 11). Thus in 1989 entrainment losses may have taken as many kokanee as the fishery. It should also be remembered that 1989 was a good year in which harvestable-sized kokanee remained at high densities (32 kokanee/hectare).

In years like 1991 recruited kokanee density dropped to 4.6 fish/hectare, presumably because entrainment losses were much higher (abundance of age 0 kokanee of this cohort was relatively normal, and fishing pressure and catch appeared lower since catch rates declined). These calculations assumed natural mortality rates remained at average values. Likely, natural mortality would have been much lower due to compensatory changes with the high entrainment losses. Thus, entrainment losses were likely underestimated.

Poor survival from age 2 to age 3 was expected since most kokanee were maturing, spawning and dying at age 2 whereas kokanee in other north Idaho lakes typically did not mature until ages 3 to 5 (Maiolie et al. 1990, Paragamian et al. 1991). Conditions in Dworshak Reservoir favored earlier maturation. Considering a mean survival rate from age 1 to age 2 of only 17%, the longer a cohort was in the reservoir the lower its numbers. For example, if a cohort matured at age 3, females would be approximately 320 mm in length and produce about 40% more eggs than an age 2 female at 280 mm (calculated from the formula $y= -947 + 5.26x$, where y = the number of eggs laid, and x is the size of a female kokanee). The numbers of females in this cohort would be reduced almost 6 fold (assuming a 17% survival rate) causing a 4.2 fold reduction in potential egg deposition. The recommendation is therefore that we do not try to alter the age at maturity of these young spawning kokanee.

Impacts

In the past the state of Idaho has calculated the dollar value of lost fish based on the potential of those fish to provide fishing opportunity. This approach was not valid in this instance since fewer kokanee in the population could trigger a variety of compensatory responses. These include better survival and growth rates of the remaining fish and increased vulnerability to angling gear of the now larger kokanee (Rieman and Meyers 1990). Both responses would tend to minimize the effect of entrainment losses.

A better method to evaluate cost of entrainment losses would be to estimate improved catch rates if the losses did not occur. In this case, angler catch rates would go from about 0.5 fish/hour to about 1.4 fish/hour which would increase harvest by 2.8 times. Sorg et al. (1985) estimated a doubling of harvest on Dworshak Reservoir would increase the worth of the fishery by 10.2% and thus a 2.8 fold increase in catch rate would equate to a 14.3% increase in worth. Net willingness to pay for a fishing trip would go up from $47.69 to $54.51/trip (in 1991 dollars, consumer price index of 134.8 of 1982 dollars). Since the fishery has

Table 11. Estimates of age 0 to 1 and age 1 to 2 kokanee entrained into Dworshak Dam, Clearwater drainage, Idaho.

Year of estimate	Number of age 0 kokanee (x 1,000)	Number of age 1 kokanee (x 1,000)	Number of age 2 kokanee (x 1,000)	Total Mortality (%)	Angler catch (Jan-July) (x 1,000)	Fishing Mortality (%)	Assumed natural mortality[1] (%)	Entrainment mortality (%)	Number entrained (x 1,000)
Ages 0 to 1									
1988	553	-	-	-	-	-	-	-	-
1989	648	165	-	70	0	0	55	15	83
1990	978	161	-	75	0	0	55	20	130
1991		208	-	79	0	0	55	24	236
Ages 1 to 2									
1988	-	501	-	-	-	-	-	-	-
1989	-	148	175	65	140	28	10	27	136
1990	-	161	-[2]	-	92	62	10	-	-
1991	-	-	19	88	-[3]	-	10	-	-

[1] Average mortality rates from Rieman and Meyers 1990.
[2] Trawling conducted too late in year for estimates.
[3] Incomplete creel survey conducted in 1991.

about 140,000 hours of pressure, (or 11,600 fishing trips), its worth (Travel Cost Method, Sorg et al. 1985) was estimated at $553,204 for current conditions but would increase to $632,316 with better catch rates. Thus, entrainment cost anglers $79,112 annually in high entrainment years. (Anglers spent an additional $686,000 for small scale expenditures for a total worth of the fishery of $1,239,000.)

This lost value does not take into account additional trips to the reservoir (and additional expenditures) that would result from the better fishing. Considering that kokanee fisherman travel widely to fish the best lakes during a given year, this represented a substantial underestimation. Rieman and Meyers (1990) found on average that fishing effort would be expected to triple as kokanee density increased from 5 to 30 kokanee/hectare. Since worth of a fishery is based on effort, value would also be expected to triple (from $413,000 in high entrainment years to $1,239,000 in low entrainment years for a cost to anglers of $826,000). Thus, this represents a much bigger impact than that based on increased catch rate.

Entrainment losses of kokanee also limit management options. If there were no entrainment losses, kokanee abundance would probably increase to the point of over-population similar to Coeur d'Alene Lake. We would then have the option of stocking a large predatory fish and greatly diversifying the fishery and increasing fishing pressure. Currently this option does not exist. If kokanee predators were to become established with this fluctuating population, there would be a very real danger of loosing the kokanee prey base. This impact (from lack of management options) is difficult to quantify, but in the case of the Coeur d'Alene Lake chinook fishery, is worth about an equal amount as the kokanee fishery.

Fluctuations of the reservoir level also had other unquantified impacts. Drawdowns reduce the area of the reservoir by 50% thus exposing and destroying much of the benthic community. Near-shore aquatic vegetation could not become established and so a potentially productive littoral zone, and its associated fish community, was lost.

Spawning Trends

Spawner counts on various tributaries to Dworshak Reservoir were conducted since 1981, although not in every year. As such, it was one of the longest data sets for the reservoir. Numbers of kokanee have ranged almost tenfold from 2,500 fish to 21,800 fish (Figure 36)(Table 6). This data set helps to put the current study into perspective. Three years of the study, 1988, 1989, and 1990 in that order, were three of the four highest spawner counts on record and presumable some of the highest adult kokanee densities as well. More "average" years occurred in the first and last years of the study which were years when no creel survey was conducted since the project was just beginning or ending. Catch rates and harvest figures from the creel surveys were therefore uncharacteristically high and not representative of most years. It does however show that the reservoir can support harvests of over 200,000 kokanee at catch rates of 1.5 fish/h if kokanee do not emigrate from the reservoir. During these "good" years, this fishery was one of the top kokanee fisheries in Idaho in terms of total catch, fishing effort, kokanee size, and catch rate (Figure 37) (Mauser et al. 1989). A recommendation for a management goal would be to strive for kokanee densities similar to 1988 or 1989; ie. 30 recruited kokanee/hectare, 20,000 kokanee in the spawner counts in Isabella, Quartz and Skull creeks, 170,000 mature kokanee in July mid-water trawl estimates, or annual catch rates for fishermen of 1.5 fish/hour. This appeared to be the optimum density of kokanee to maximize length (at 285 mm), catch

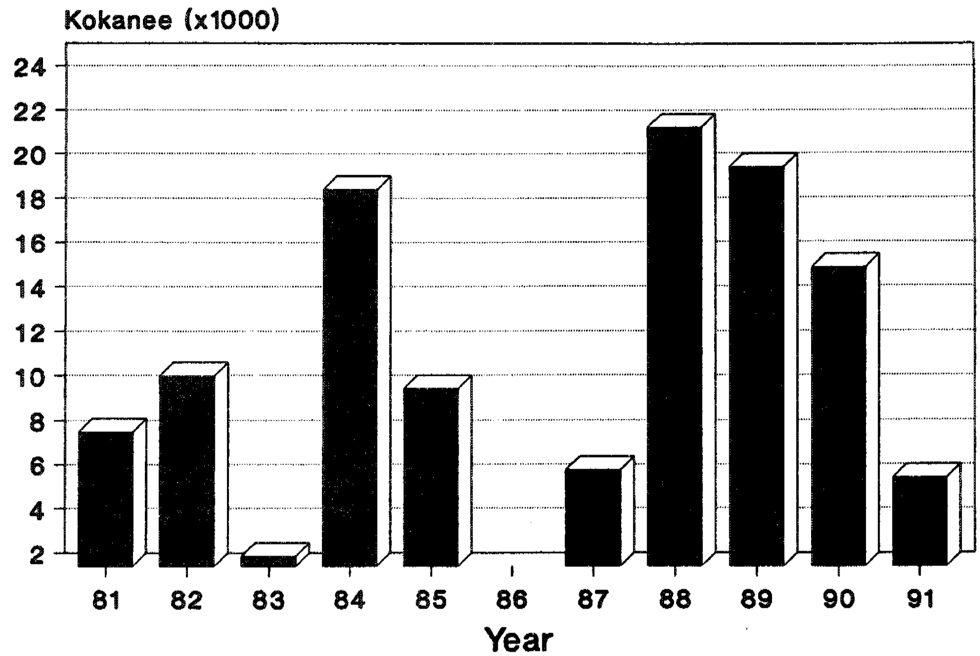


Figure 36. Number of kokanee spawners in Isabella, Skull, and Quartz tributaries to Dworshak Reservoir, Idaho, 1981-1991.

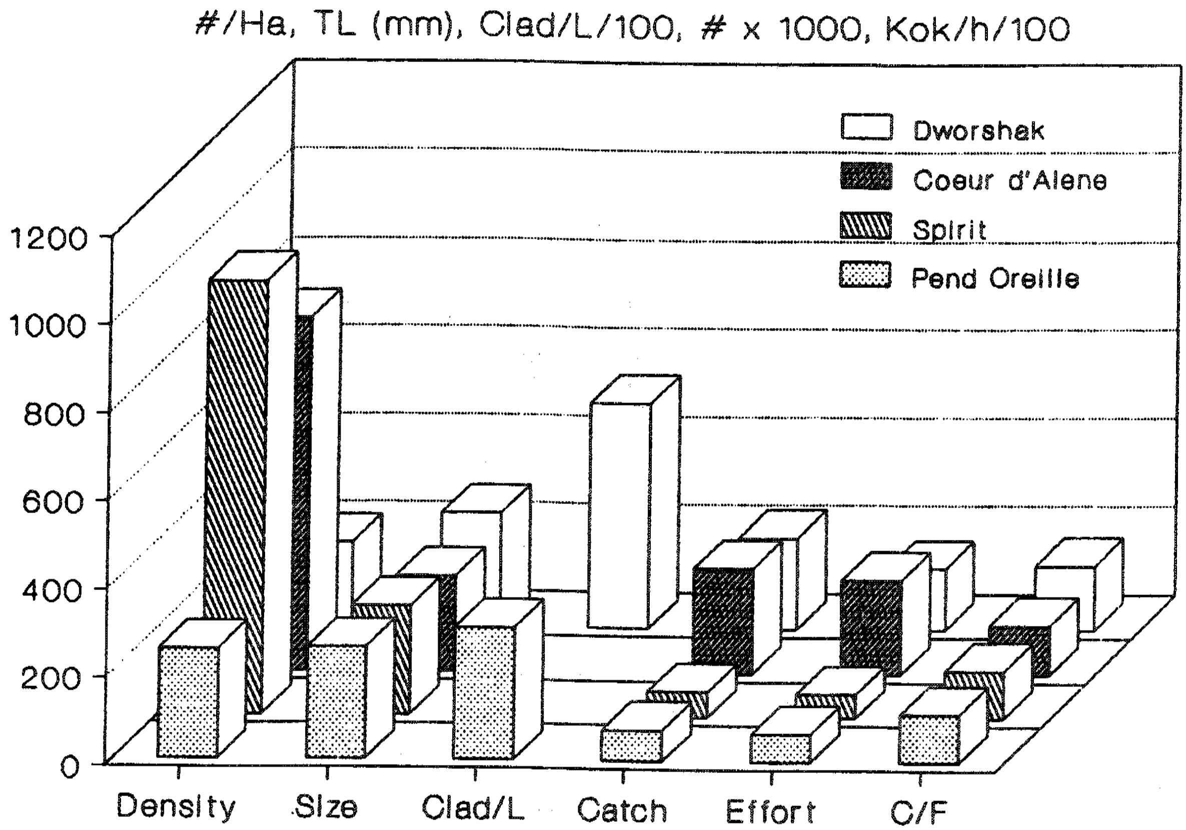


Figure 37. Density, mean size in harvest, cladoceran abundance, total estimated angler catch, effort, and success for kokanee fisheries on Pend Oreille, Spirit, Coeur d'Alene lakes and Dworshak Reservoir, Idaho.

rate in the fishery, and potentially kokanee yield (Rieman and Meyers 1990).

Spawner counts, and thus the mature kokanee population in the reservoir, was found to correlate to the amount of discharge from the dam the previous year ($r^2 = 0.47$) and the amount of spill from the dam the previous year ($r^2 = 0.26$)(Figures 38 and 39). Because of the one year lag time it appeared that entrainment losses were primarily affecting age 1 kokanee. These findings strongly support the conclusion that the low kokanee densities and the resulting poor fisheries were due to entrainment losses to Dworshak Dam.

Entrainment

Our expectations were that kokanee entrainment would be highest in the spring and positively correlated with discharge, and negatively correlated to reservoir elevation and depth of water withdrawal. These relationships were not observed (Figures 7 and 8). The only trend observed was that entrainment rates were low when discharge was below 212 m^3/s (Figure 7).

These findings do not indicate the expected relationships do not exist. A much more likely conclusion was that the methodology was insufficient to define them. At the highest flows, kokanee probably were flushed through the North Fork rather quickly and so were missed in the counts. As many as 10 bald eagles, 5 ospreys, a dozen seagulls, and numerous mergansers and buffleheads were feeding on kokanee in the river and thus may have reduced our trend counts. Also, water clarity changed with flows and likely added additional variation. Our recommendation is that any future studies on kokanee entrainment be conducted with hydroacoustic gear mounted on (or in) the dam, or by nets placed within the turbine outflows.

TROUT, BASS AND FORAGE SPECIES

Abundance

The declining gill net catch rates a few years after initial inundation correspond to the productivity shift from eutrophy to oligo-mesotrophy as reported in the Limnology section of this document. Temporal analysis of receding redside shiner abundance and increasing smallmouth bass abundance suggests that the redside shiner was in decline prior to the reservoir-wide expansion of the smallmouth bass populations. Reduced productivity from reservoir aging and deterioration of shoreline spawning habitat from pool fluctuations are what likely triggered the redside shiner decline, rather than smallmouth bass predation. Smallmouth bass populations were expanding during a previously induced decline of a major prey base. Chisholm et al. (1989) noted that extensive shoreline erosion at Libby Reservoir, Montana, eliminated flooded vegetation used as spawning substrate by redside shiners. The absence of shoreline vegetation caused by shoreline erosion was identified by Chisholm et al. (1989) as a likely primary factor limiting redside shiner abundance.

Current catch rates and relative abundance of smallmouth bass compared with prior years suggest that this species is well established throughout the reservoir. Smallmouth bass is currently the most abundant naturally producing littoral based game fish species in Dworshak Reservoir.

To mitigate for losses to the resident fishery resulting from construction of Dworshak Dam, the USACE funds the U.S. Fish & Wildlife

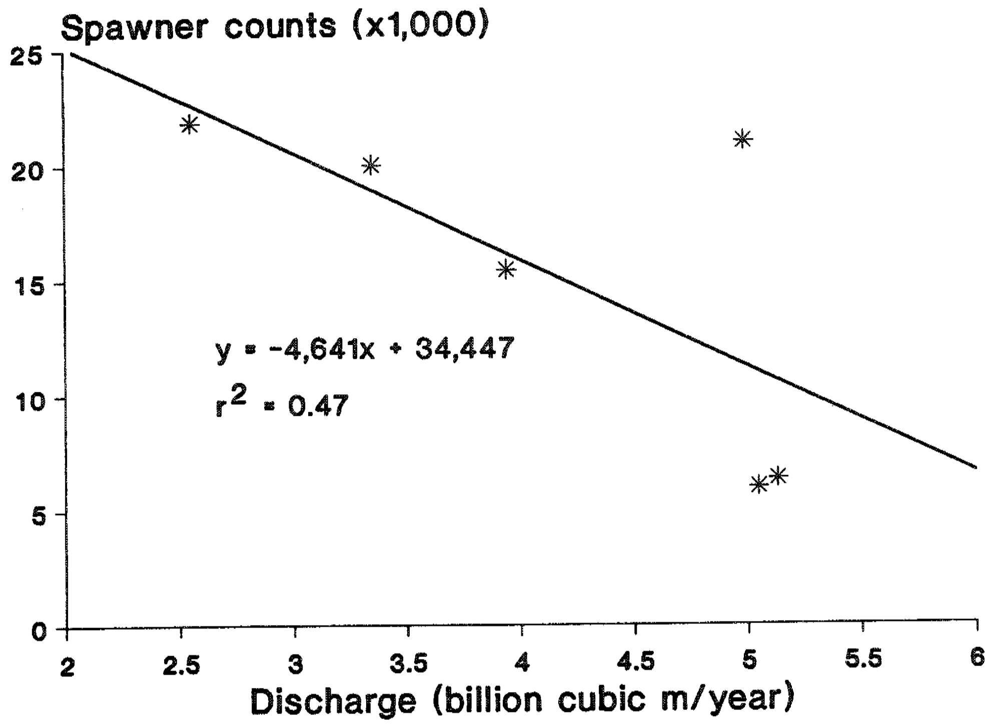


Figure 38. Relationship between the amount of water discharged from Dworshak Dam from July 1 to June 30 and the number of kokanee spawners the following year in Isabella, Quartz, and Skull Creeks.

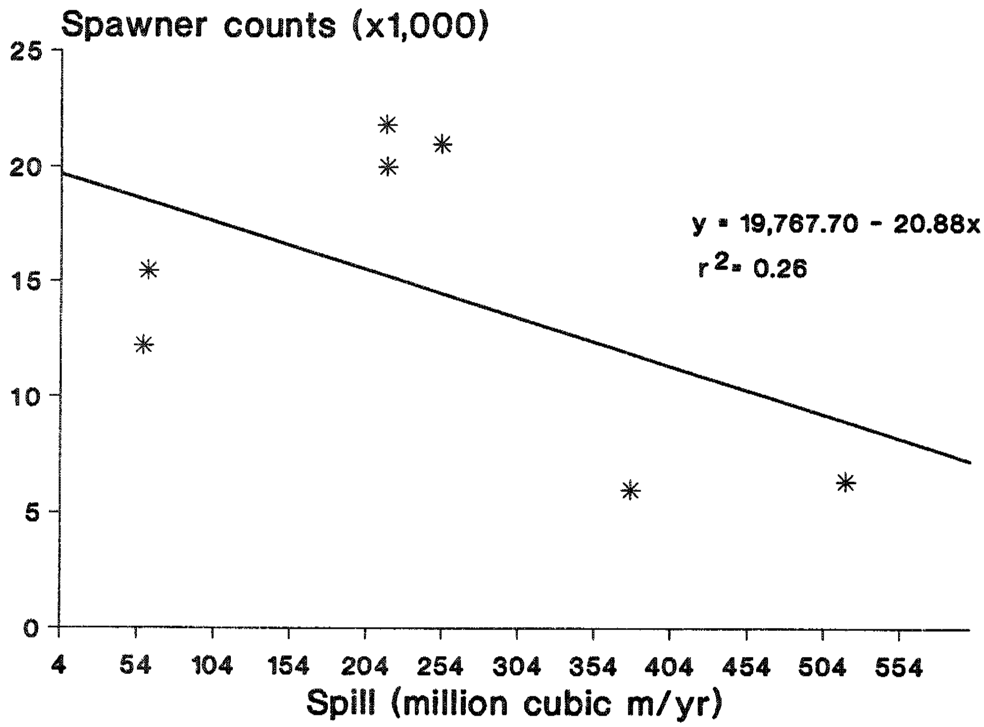


Figure 39. Relationship between the amount of water spilled from Dworshak Dam from July 1 to June 30 and the number of kokanee spawners the following year in Isabella, Quartz, and Skull Creeks.

Service to stock hatchery rainbow trout. This stocking program was initiated in 1972 and has continued to the present time. Ball and Cannon (1973) reported that, during 1972, marked fingerling rainbow trout released near Dent Bridge dispersed rapidly and were caught in gill nets at the upper end of the reservoir 3 months after stocking. Ball and Pettit (1974) reported angler harvest of the this same marked release group during 1973 as far as Kelly Creek, some 88 km upstream from Dworshak Reservoir. Statler (1989, 1990) also collected marked hatchery rainbow trout in the upper end of the reservoir, following liberation in the lower reservoir area.

The distribution and abundance of westslope cutthroat trout have drastically declined from its historic range during the last 100 years (Liknes and Graham 1988). Although once present in virtually all Idaho waters north of and including the Salmon River drainage (approximately 10,000 stream miles), Rieman and Apperson (1989) judged that strong populations of westslope cutthroat trout remain in only 11% of this historic range. Strong and genetically pure populations exist in probably less than 4% of the historic range in Idaho (Rieman and Apperson 1989). The decline of the westslope cutthroat trout has been attributed to overexploitation, genetic introgression, competition from or replacement by nonnative species and habitat degradation.

Liknes and Graham (1988) indicated that important populations of westslope cutthroat trout still occur in the North Fork Clearwater drainage. Reiman and Apperson (1989) noted strong populations of westslope cutthroat trout in several North Fork Clearwater tributaries upstream from Dworshak Reservoir, including Cayuse Creek, Fourth of July Creek, Kelly Creek and Weitas Creek.

The same factors that have contributed to the general decline of westslope cutthroat trout populations have impacted the subspecies in the North Fork Clearwater Basin. Actions have been taken to address some of these problems. Specifically, exploitation has been reduced in Kelly Creek, a major tributary, through catch-and-release only trout fishing. Other waters upstream from Dworshak Reservoir, and the upper end of Dworshak Reservoir proper (Grandad Bridge upstream), are regulated by a 2 trout possession limit, 4 less than statewide possession limit of 6. Hatchery stocking of rainbow trout in waters upstream from Dworshak Reservoir was discontinued in 1981. There is an ongoing effort by Federal, State and Tribal fishery agencies to coordinate with the U.S. Forest Service to address habitat deterioration from land management activities.

The stocking of hatchery rainbow trout for resident fish mitigation may be incompatible with other measures in the North Fork Clearwater Basin directed towards restoring and perpetuating the endemic native westslope cutthroat trout. The stocking program presents a risk of genetic introgression to this native population, considering the documentation of rapid and extensive dispersal of hatchery rainbow trout released in Dworshak Reservoir, as well as the occurrence of cutthroat trout-rainbow trout hybrids in the upper reservoir extremities.

Dworshak Reservoir should not be viewed as a closed system with respect to rainbow trout stocking activities. Because continued rainbow trout stocking in Dworshak Reservoir could augment the risk of genetic introgression, we strongly recommend a genetic inventory analysis of westslope cutthroat trout populations from Dworshak Reservoir into the upper reaches of the North Fork Clearwater drainage. This information would help in evaluating the risks involved with stocking rainbow trout in Dworshak Reservoir, and in determining if modification to the existing resident fish mitigation program is warranted.

As an interim measure, trout stocking in Dworshak Reservoir should not exceed the recent levels (approximately 10,000 kg). Catchable size fish (≤ 13 fish per kg or 6 fish per pound) are preferred because they apparently do not diperse as widely or rapidly in the drainage (Ball and Pettit 1974).

Growth

Hatchery Rainbow Trout Strains - There was no appreciable difference in growth observed among the two strains of rainbow trout (Shasta and Arlee) tested. Releasing 140 mm rainbow trout in early May provides as large a fish to the following winter fishery as planting 160 mm trout in early June. In addition to requiring less rearing time in the hatchery, the early May release promotes utilization of seasonal reservoir productivity and offers cooler surface water temperatures to minimize stress during stocking. Although both the Shasta and Arlee strains stocked as subcatchables during early spring are suitable for a put-and-grow program, stocking of catchable trout for a put-and-take fishery is preferred due to the reasons noted in the above discussion on "Abundance."

Smallmouth Bass - Despite the post-1980 decline in growth rates of smallmouth bass, Dworshak Reservoir bass continue to achieve average growth when compared to the mean growth compiled by Bennett and Dunsmoor (1986) for bass populations at similar latitudes. Dworshak smallmouth bass approximate a slow growth pattern as described by Anderson and Weithman (1978).

Food Habits

Rainbow Trout - The sizeable contribution of Hymenoptera, mostly ants, and Homoptera in the stomachs analyzed highlights the importance of terrestrial insects to the diet of Dworshak Reservoir rainbow trout. Pettit (1976) also noted the high occurrence of terrestrial beetles and ants in rainbow trout stomachs collected in 1972, 1974, and 1975. Maintenance of the forested environment surrounding Dworshak Reservoir is important for the continued contribution of terrestrial insects as fish food. Chisholm et al. (1989) associated lower numbers of surface terrestrial invertebrates in Libby Reservoir, Montana, with increased distance from the water to shoreline vegetation. The distance from water to shoreline vegetation increased during reservoir drawdown, with the most pronounced effect in large bays and shallow water areas.

Smallmouth Bass - Pettit (1976, 1977) reported a smallmouth bass diet consisting exclusively of fish and crustaceans. The diet diversity of Dworshak Reservoir smallmouth bass has apparently increased since the late 1970's. This was likely necessitated by the collapse of the formerly abundant redside shiner population. Although the importance of terrestrial insects (particularly Hymenoptera and Coleoptera) to trout has been previously reported by Pettit (1976, 1977), their importance as food for smallmouth bass has not been previously documented.

The availability of larval fish prey, especially squawfish, to young-of-the-year smallmouth bass contributes to sizeable first year growth approaching 100 mm. Aggus and Elliott (1975) reported age 0+ largemouth bass that fed predominantly on fish grew faster than those that fed mostly on invertebrates. Oliver and Holeton (1979) showed that increased size of age 0+ smallmouth bass improved overwinter survival.

Smallmouth Bass Mortality

Mortality indices suggest a moderate total annual mortality that is not appreciably influenced by the current rate of exploitation of age 5 and older bass. The minimal effect of exploitation on total instantaneous mortality is currently driven by a modest harvest of legal size bass ≥ 305 mm. The estimated annual harvest of smallmouth bass for 1988 through 1990 averaged less than 1,000 fish. Anglers kept only 7.6% (2,769) of the estimated 36,670 smallmouth bass caught from 1988 through 1990.

Smallmouth Bass Length-Weight Structural Indices

__Proportional Stock Density__ - The observed PSD value of 23.1 is close to the PSD of 22 proposed by the Anderson and Weithman (1978) smallmouth bass population model depicting moderate total annual mortality (.43) with slow growth. The population structure of stock and quality sized smallmouth bass in Dworshak Reservoir is reasonably balanced commensurate with current productive capacity.

__Relative Weight__ - Smallmouth bass from 101-200 mm and 201-300 mm exhibited W_r values of 88.0 and 88.1, respectively, suggesting greater competition for food within these size groups. Food limitations could be intensified by strong year classes competing for food within a narrow band of smallmouth bass habitat along Dworshak's precipitous shoreline. Low mortality and lack of a predominant forage fish prey base may also amplify food competition. Although diet analysis has identified larval squawfish as a major target prey for young-of-the-year bass, this species soon grows beyond a size suitable for early age (Age 1-4) foraging.

The wide range of individual W_r values for the smallest size class (≤100 mm) was probably due to inadequate scale sensitivity at the lesser weights.

Smallmouth Bass Equilibrium Yield Model

The purpose of a minimum length limit is to protect from exploitation that portion of a population that is smaller than the limit (Coble 1975). Fox (1975) noted that studies evaluating the effect of size limits on bass populations in different waters showed varying results regarding advantages and disadvantages of size limits. Fox (1975) and Paragamian (1982) stressed the need to consider site specific fish population dynamics and exploitation when assigning size limit restrictions. Fox (1975) cautioned against statewide or general size limit restrictions, stating that such an approach could be disadvantageous to sound management programs.

Ricker (1975) stated that the smaller the fishing rate, the broader the range of sizes that should be taken-that is, the smaller should be the minimum size limit. Application of the existing statewide 305 mm size limit for Dworshak Reservoir smallmouth bass is probably overly restrictive, considering the relatively low fishing pressure and exploitation. Modeling based on reservoir specific growth, mortality and exploitation suggests that reduction of the legal size limit to 254 mm would increase the total number and weight of bass harvested, with minimal impact to older bass.

The application of minimum size limits on a bass fishery will influence forage, as well as bass population structure (Fox 1975). Harvest at age 4 (254 mm) rather than age 5 (305 mm) could relieve intra-specific food competition at the age of peak biomass (age 4) and improve W_r values. If a 254 mm minimum size limit were to be implemented, review of the regulation would be in order should factors such as exploitation rate or reproductive success appreciably change.

Limnology

Phosphorous is an essential nutrient for aquatic biota. Relative to other major nutritional and structural components, phosphorous is least abundant and commonly limits biological productivity (Wetzel 1975). "The most important quantity, in the view of the metabolic characteristics within a lake is the total phosphorus content of unfiltered water which consists of the phosphorus in suspension in particulate matter, and the phosphorus in 'dissolved' form (Wetzel 1975)." As a limiting element phosphorus levels have been used to characterize lake productivity. Lakes having less than 5 micro g/L are classed as ultra-oligotrophic, 5 to 10 micro g/L as oligo-mesotrophic, and 10 - 30 micro g/L as meso-eutrophic (Wetzel 1975).

The lower open water section of Dworshak Reservoir was characterized as oligo-mesotrophic by its 9 micro g/L of total phosphorus. Thus, it was a relatively sterile environment consistent with undeveloped mountainous watershed of crystalline geomorphology (the Idaho Batholith). The Elk Creek arm was classed as meso-eutrophic (12 micro g/L of total phosphorus); somewhat richer than the main lake. Undoubtedly nutrients are being added to the bay from Elk Creek which flows through the town of Elk River.

Falter et al. (1979) characterized Dworshak Reservoir as eutrophic in 1972 but tending towards mesotrophy in 1973 and 1974 (based on oxygen deficit). They also calculated seasonal ortho-phosphate values of 19 micro g/L in 1972, 11 - 14 micro g/L in 1973, and 11 to 17 micro g/L in 1974 at RK-6. Our study found ortho-phosphate values often below detection limits of 1 micro g/L and we characterized the trophic status as oligo-mesotrophic based on total phosphorus. Thus, we safely concluded Dworshak reservoir has become a much more sterile environment for aquatic biota, including sportfish.

Fish standing crop and sportfish harvest are of particular interest to fishery managers. Both of these levels are largely dependant on the reservoirs nutrient status and thus have been correlated to it. Jones and Hoyer (1982) correlated sportfish yield to total phosphorus for lakes and reservoirs in Missouri and Iowa. The relationship was quite good ($r=0.72$, $p \leq 0.01$) considering the lakes covered a wide range of inorganic turbidity and a wide range of surface area. To this regression we added data from Idaho lakes including Dworshak Reservoir (Figure 40) (Appendix H). A similar graph was constructed for the relationship between chlorophyll a and sportfish harvest (Figure 41). Based on these relationships we concluded that sportfish harvest at Dworshak Reservoir, in years when density of kokanee was high, was above what could generally be expected based on its nutrient status. High harvest can be attributed to kokanee feeding low on the food chain, the absence of predators, and a high amount of fishing effort.

Temperature data collected in the near-shore shallow water habitat zone during 1991 indicated that water temperatures would approach 15 C by June 1. This approximates the threshold temperature identified by Coble (1975) and Piper et al. (1982) for the commencement of smallmouth bass spawning activity.

Bottom temperatures from stationary recording temperature sensors showed temperature depressions associated with rising pool elevations during the spring. Pool fluctuations of +.23 m/day over a 22 day period in June were accompanied by a temperature drop 14.0 to 10.3 C. According to Coble (1975), male smallmouth bass may guard the nest from

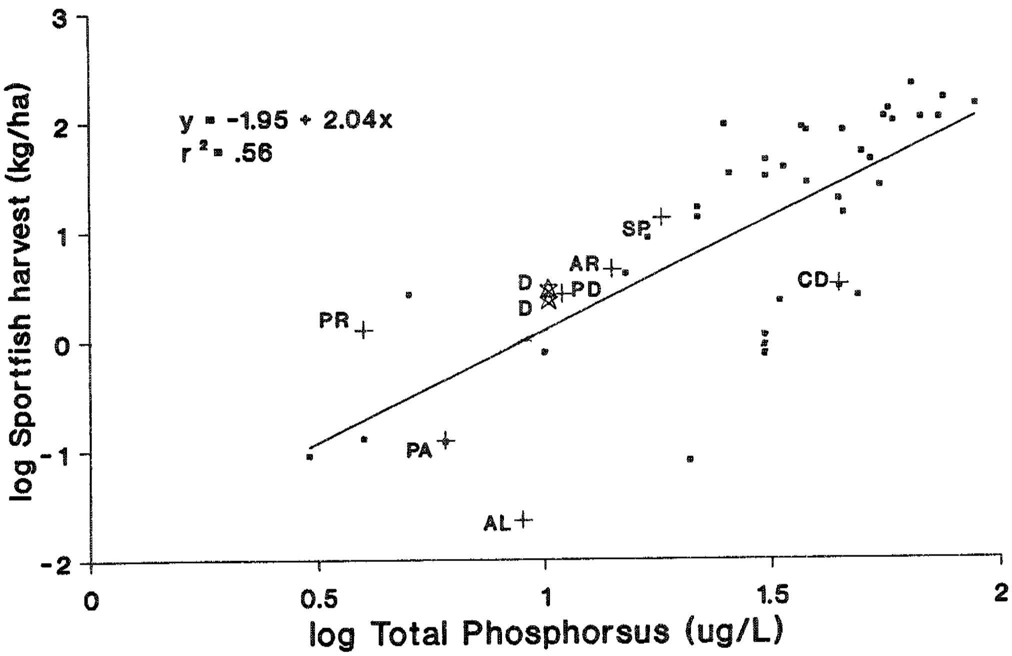


Figure 40. Total Phosphorus and sportfish harvest for lakes and reservoirs in Iowa and Missouri (Jones and Hoyer, 1982) and for Idaho (Rieman and Meyers, 1990) and for Dworshak Reservoir (Mauser et al, 1989)(Mauser et al, 1990) and for other waters (Rieman and Meyers, 1991). Note: All Idaho and other waters are kokanee harvest only. (AL-Alturus Lake, AR-Anderson Ranch Reservoir, CD-Coeur d'Alene Lake, D-Dworshak Reservoir, PA-Payette Lake, PD-Pend Oreille Lake, PR-Priest Lake, SP-Spirit Lake).

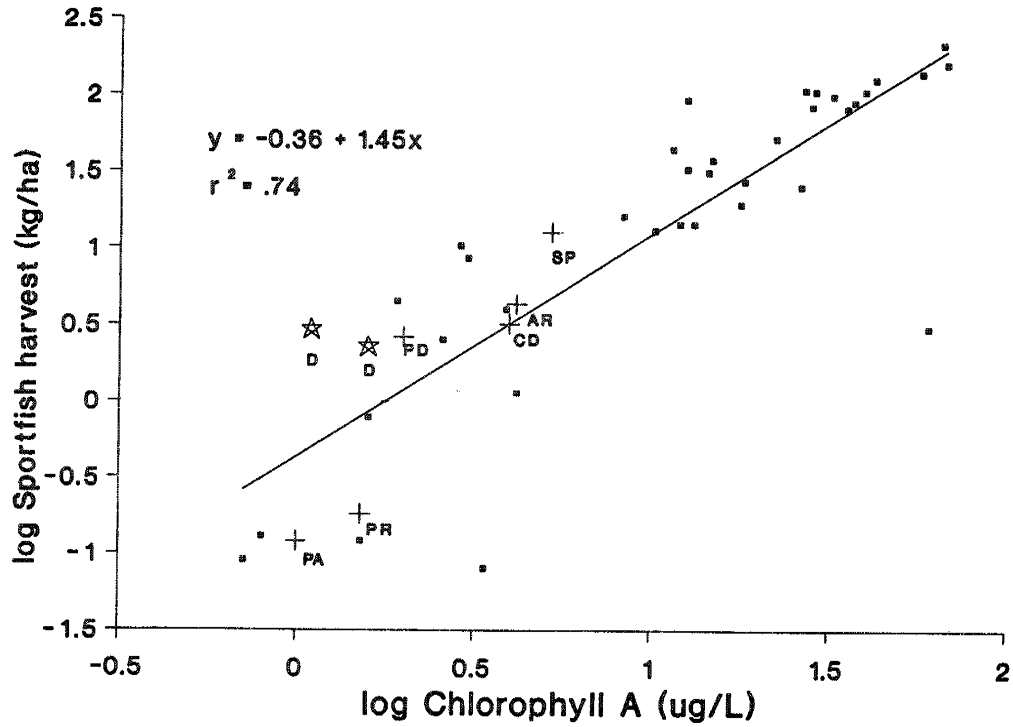


Figure 41. Total chlorophyll A and sportfish harvest for lakes and reservoirs in Iowa and Missouri (Jones and Hoyer, 1982) and for Idaho (Rieman and Meyers, 1990) and for Dworshak Reservoir (Mauser et al, 1989)(Mauser et al, 1990) and for other waters (Rieman and Meyers, 1991).
Note: All Idaho and other waters are kokanee harvest only. (AR-Anderson Ranch Reservoir, CD-Coeur d'Alene Lake, D-Dworshak Reservoir, PA-Payette Lake, PD-Pend Oreille Lake,PR-Priest Lake, SP-Spirit Lake).

predation for a month or more from the time of egg deposition to fry dispersal. Guarding male bass desert nests when temperatures are reduced from near 15 C to near 10 C. Temperature depressions associated with rising pool levels in Dworshak Reservoir were of sufficient magnitude to cause nest abandonment prior to fry dispersal. Reduced survival from increased predation would be the primary consequence from nest abandonment. Survival of eggs is also reduced if temperatures fall below 15 C during the 2-10 d incubation period (Coble 1975).

Smallmouth bass are capable of renesting if adverse conditions abort the initial attempt (Coble 1975). A second spawning period may occur a month or more after the initial attempt.

Smallmouth bass spawning during June is likely being impaired due to decreases in water temperature at nest locations caused by rising pool levels. Despite this impediment, successful reproduction of smallmouth bass occurs because: renesting can follow an aborted attempt; a stable full pool is maintained from July 1 through September 1, and; the period from egg deposition to fry dispersal is brief. Under the current operational criteria for Dworshak Dam, that provide a stable full pool during the July 1 through September 1 recreation period, reproduction of smallmouth bass is not a limiting factor.

Declining pool levels after June 1, when suitable spawning temperatures are achieved, would likely result in nest desiccation and reproductive failure for smallmouth bass.

Creel Survey

Kokanee fishing by boat anglers dominates the Dworshak Reservoir fishery during the prime recreation season from March through September. During 1990, 113,297 hours of kokanee fishing accounted for 75.7% of the total effort (149,592), and the kokanee catch of 94,757 comprised 74.0% of the total fish caught (128,000). Fishing for rainbow trout by bank anglers is the primary activity from October through February, however this is also the period with the least angling effort.

The incidental catch rate of subcatchable hatchery rainbow trout by boat anglers targeting on kokanee was .06 fish/h in 1990, compared to .17 fish/h and .13 fish/h in 1988 and 1989, respectively. The reduced incidental catch rate in 1990 followed a May stocking of 130 mm rainbow trout. This stocking was one month earlier, with fish about 30 mm smaller, than 1988 and 1989. Data suggests that the 1990 strategy of an earlier stocking of smaller rainbow trout contributed to reducing incidental catch of stocked rainbow trout by kokanee anglers. The cumulative catch rate for rainbow trout by bank anglers from October through December 1990 was 1.91 fish/h, compared to catch rates of .56 fish/h and 1.14 fish/h during the same period in 1988 and 1989, respectively. The improved success for catching rainbow trout during the 1990 winter fishery was likely influenced by the reduced incidental catch of rainbow trout by kokanee anglers.

RECOMMENDATIONS

1. An appropriate goal for this kokanee population would be to attempt to manage for a density of 30 to 40 adult kokanee/hectare. To accomplish this goal entrainment losses need to be reduced. We therefore recommend pursuing methods to avoid or minimize entrainment. This could greatly enhance and stabilize the kokanee fishery. Behavioral avoidance devices which should be considered include (but are not limited to) strobe lights, pneumatic hammers, bubble screens and sound generators (McKinley et al. 1989).

2. Do not stock fish which prey on kokanee as an attempt to diversify the fishery unless their sterility can be assured and their numbers limited. If a predator population became established, they could severely reduce the kokanee population in years when entrainment losses are high. The depensatory mortality could keep the population from increasing in subsequent years and would likely extricate kokanee from the reservoir. Based on the history of other kokanee lakes, attempts to reestablish kokanee at that point may be futile.

3. Do not attempt to increase age at maturity of these kokanee stocks unless high entrainment losses can be avoided. Younger spawning may be a mechanism to keep egg deposition high.

4. Mid-water trawling should be conducted annually to further define the relationship between the fishery, kokanee densities, and the water year. Once these relationships are developed, it may be possible to determine the effects of our kokanee entrainment reduction efforts.

5. Continue kokanee spawner counts at least in Isabella, Quartz, Dog, and Skull Creeks on September 25 of each year. These data should be correlated to the abundance of mature kokanee based on trawling so that either data set could be used.

6. Kokanee spawners appear to have more than a sufficient amount of area for spawning. The practice of dynamiting rock barriers in tributary streams is therefore of questionable worth.

7. Conduct a pilot test to determine the feasibility of an active revegetation program following methods described in "Reservoir Shoreline Revegetation Guidelines," by H.H. Allen and C.V. Klimas, U.S. Army Corps of Engineers Technical Report E-86-13, 1986. Establishment of permanent vegetation at suitable sites would improve the shoreline environment that has been denuded and degraded by the fluctuating water levels caused by operation of Dworshak Dam. Providing living shoreline cover would partially restore littoral habitat and food production potential that has been lost. Shoreline restoration efforts would be particularly beneficial to littoral species such as smallmouth bass, but may also benefit pelagic species such as kokanee by reducing inorganic turbidity.

8. Conduct a genetic inventory of cutthroat trout in the North Fork Clearwater drainage to determine the genetic purity of the endemic westslope cutthroat trout and to ascertain the extent of genetic introgression. If rainbow trout are determined to be a source of genetic deterioration for endemic westslope cutthroat trout populations, rainbow trout stocking for

resident fish mitigation should be relocated off-site and outside of the North Fork Clearwater Basin. Alternative off-site stocking locations should be selected so as to avoid conflict with wild/natural anadromous and endemic resident fish. Trout stocking in Dworshak Reservoir should be confined to westslope cutthroat trout or bull trout from broodstock endemic to the North Fork Clearwater drainage.

9. If rainbow trout stocking is continued in Dworshak Reservoir, then we recommend periodic genetic monitoring of westslope cutthroat trout upstream from Dworshak Dam.

10. If the management goals are to increase yield and attempt to improve body condition of 254 mm to 305 mm smallmouth bass, we recommend reducing the minimum length limit for smallmouth bass from 305 mm (12 inches) to 254 mm (10 inches). The minimum length limit should be reevaluated if changes in dam operation negatively impact reproduction or if angling pressure targeting on smallmouth bass appreciably increases.

11. Avoid downward fluctuations in pool level from June 1 through August 31 to prevent dewatering smallmouth bass nests. This measure would promote the continued reproductive viability of smallmouth bass, but would need to be reviewed with threatened or endangered anadromous fish requirements.

12. Achieve normal full pool during June, if flood run-off forecasting allows, to avoid rising pool levels and associated temperature depressions in near-shore areas when smallmouth bass are spawning.

13. Do not initiate reservoir evacuation for winter flood control or hydropower prior to the September 1 date earmarked in the U.S. Army Corps of Engineers' current flood control operating curve. A full pool through August 31 promotes terrestrial invertebrates deposition, an important source of food for trout and smallmouth bass. The authors do recognize, however, that drawdowns during this period could be required to protect threatened or endangered anadromous fish.

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Appendix A. Date, location, weight, number, and length of Shasta and Arlee strain rainbow trout released in Dworshak Reservoir Reservoir during 1988 by the U.S. Fish & Wildlife Service.

Date	Strain	Fin Clip[1]	Location[2]	Weight kg (lbs)	Number	Fish/ lb	Length (mm)
05/31/88	Arlee	rv	Bruce's Eddy	363 (800)	8128	10.16	159
05/31/88	Arlee	rv	Opposite Bruce's Eddy	363 (800)	8128	10.16	159
05/31/88	Arlee	rv	Big Eddy	340 (750)	7620	10.16	159
05/31/88	Arlee	rv	Big Eddy	363 (800)	8272	10.34	158
05/31/88	Arlee	rv	Point opposite Big Eddy	363 (800)	8272	10.34	158
05/31/88	Arlee	rv	Freeman Creek	363 (800)	8404	10.51	157
05/31/88	Arlee	rv	Freeman Creek	363 (800)	8800	11.00	155
05/31/88	Arlee	rv	Canyon Creek	363 (800)	8800	11.00	155
05/31/88	Arlee	rv	Canyon Creek	363 (800)	8509	10.64	157
05/31/88	Arlee	rv	Indian Creek	363 (800)	8024	10.03	160
06/02/88	Arlee	rv	Dick's Creek	363 (800)	8024	10.03	160
06/02/88	Arlee	rv	Elk Creek Arm rk 4.0	363 (800)	9125	11.41	153
06/02/88	Arlee	rv	Elk Creek Arm rk 4.0	363 (800)	9160	11.45	153
06/02/88	Arlee	rv	Elk Creek Arm rk 1.3	363 (800)	9053	11.32	154
06/02/88	Arlee	rv	Dent Acres	363 (800)	8816	11.04	155
06/02/88	Arlee	rv	Dent Acres	340 (750)	8265	11.02	155
06/02/88	Arlee	rv	Dent Bridge	227 (500)	5510	11.02	155
06/02/88	Shasta	lv	Dent Acres	363 (800)	8928	11.16	154
06/02/88	Shasta	lv	Dent Acres	363 (800)	8928	11.16	154
06/02/88	Shasta	lv	Dent Bridge	136 (300)	3348	11.16	154
06/02/88	Shasta	lv	Elk Creek Arm rk 1.3	327 (720)	8035	11.16	154
06/06/88	Shasta	lv	Bruce's Eddy	363 (800)	8888	11.11	155
06/06/88	Shasta	lv	Opposite Bruces Ed	363 (800)	8888	11.11	155
06/06/88	Shasta	lv	Big Eddy	340 (750)	8333	11.11	155
06/06/88	Shasta	lv	Big Eddy	363 (800)	8288	10.36	158
06/06/88	Shasta	lv	Point Opp. Big Eddy	363 (800)	8288	10.36	158
06/06/88	Shasta	lv	Freeman Creek	363 (800)	8288	10.36	158
06/06/88	Shasta	lv	Freeman Creek	363 (800)	8084	10.11	159
06/06/88	Shasta	lv	Canyon Creek	363 (800)	8016	10.02	160
06/06/88	Shasta	lv	Canyon Creek	363 (800)	8016	10.02	160
06/06/88	Shasta	lv	Indian Creek	363 (800)	7930	9.91	161
06/08/88	Shasta	lv	Elk Creek Arm rk 4.0	454 (1000)	9680	9.68	162
06/08/88	Shasta	lv	Elk Creek Arm rk 4.0	250 (550)	5236	9.52	163
06/08/88	Shasta	lv	Elk Creek Arm rk 8.0	454 (1000)	9680	9.68	162
06/08/88	Shasta	lv	Elk Creek Arm rk 8.0	363 (800)	7624	9.53	163
06/08/88	Shasta	lv	Dick's Creek	454 (1000)	9520	9.52	163
Subtotal Shasta and weighted mean length				6774 (14920)	153998		158
Subtotal Arlee and weighted mean length				5993 (13200)	140910		157
Total				12767 (28120)	294908		

[1] Fin clip abbreviations are: lv = left pelvic (ventral)
rv = right pelvic (ventral).

[2] Abbreviation "rk" indicates river kilometer.

Appendix A. Date, location, number, weight and length of Shasta and Arlee strain rainbow trout released in Dworshak Reservoir during 1989 by the U.S. Fish & Wildlife Service.

Date	Strain	Fin Clip[1]	Location[2]	Weight kg	(lbs)	Number	Fish/ lb	Length (mm)
06/01/89	Shasta	lvad	Indian Creek	363	(800)	9144	11.43	153
06/01/89	Shasta	lvad	Canyon Creek	363	(800)	9144	11.43	153
06/01/89	Shasta	lvad	Canyon Creek	116	(255)	2915	11.43	153
06/01/89	Shasta	lvad	Canyon Creek	247	(545)	6289	11.54	152
06/01/89	Shasta	lvad	Freeman Creek	363	(800)	9232	11.54	152
06/01/89	Shasta	lvad	Freeman Creek	245	(540)	6232	11.54	152
06/01/89	Shasta	lvad	Freeman Creek	86	(190)	2084	10.97	155
06/01/89	Shasta	lvad	Bruce's Eddy	363	(800)	8496	10.62	157
06/01/89	Shasta	lvad	Opposite Bruce's Eddy	363	(800)	8496	10.62	157
06/01/89	Shasta	lvad	Big Eddy	182	(400)	4248	10.62	157
06/01/89	Shasta	lvad	Big Eddy	182	(400)	4388	10.97	155
06/01/89	Shasta	lvad	Big Eddy	363	(800)	8776	10.97	155
06/01/89	Shasta	lvad	Point opposite Big Eddy	363	(800)	8776	10.97	155
06/06/89	Shasta	lvad	Dent Acres	363	(800)	8272	10.34	158
06/06/89	Shasta	lvad	Dent Acres	363	(800)	8272	10.34	158
06/06/89	Shasta	lvad	Dent Bridge	250	(550)	5687	10.34	158
06/06/89	Shasta	lvad	Dent Bridge	114	(250)	2535	10.14	159
06/06/89	Shasta	lvad	Elk Creek Arm rk 1.3	359	(790)	8011	10.14	159
06/06/89	Shasta	lvad	Elk Creek Arm rk 4.0	363	(800)	8112	10.14	159
06/06/89	Arlee	rvad	Dent Acres	351	(774)	7590	9.80	161
06/06/89	Arlee	lvad	Dent Acres	12	(26)	250	9.80	161
06/06/89	Arlee	rvad	Dent Acres	351	(774)	7590	9.80	161
06/06/89	Arlee	lvad	Dent Acres	12	(26)	250	9.80	161
06/06/89	Arlee	rvad	Dent Bridge	198	(436)	4273	9.80	161
06/06/89	Arlee	lvad	Dent Bridge	6	(14)	141	9.80	161
06/06/89	Arlee	rvad	Dent Bridge	159	(350)	3455	9.87	161
06/06/89	Arlee	rvad	Elk Creek Arm rk 1.3	363	(800)	7896	9.87	161
06/06/89	Arlee	rvad	Elk Creek Arm rk 4.0	363	(800)	7896	9.87	161
06/08/89	Arlee	rvad	Indian Creek	318	(700)	7616	10.88	156
06/08/89	Arlee	rvad	Canyon Creek	318	(700)	7616	10.88	156
06/08/89	Arlee	rvad	Canyon Creek	318	(700)	7616	10.88	156
06/08/89	Arlee	rvad	Freeman Creek	213	(470)	5114	10.88	156
06/08/89	Arlee	rvad	Freeman Creek	104	(230)	2450	10.65	157
06/08/89	Arlee	rvad	Freeman Creek	318	(700)	7455	10.65	157
06/08/89	Arlee	rvad	Bruce's Eddy	318	(700)	7455	10.65	157
06/08/89	Arlee	rvad	Opposite Bruce's Eddy	313	(690)	7349	10.65	157
06/08/89	Arlee	rvad	Big Eddy	363	(800)	8120	10.15	159
06/08/89	Arlee	rvad	Bid Eddy	359	(790)	8019	10.15	159
06/08/89	Arlee	rvad	Point opposite Big Eddy	363	(800)	8120	10.15	159
Subtotal Shasta and weighted mean length (mm)				5412	(11920)	129109		156
Subtotal Arlee and weighted mean length (mm)				5121	(11280)	116271		158
Total				10533	(23200)	245380		

[1] Fin clip abbreviations are: lvad = left pelvic (ventral) and adipose clip
rvad = right pelvic (ventral) and adipose clip.

[2] Abbreviation "rk" indicates river kilometer.

Appendix B. Spreadsheet formats for application of a 1,000 recruit equilibrium yield model (Ricker 1975) for 254 mm and 305 mm length limits for smallmouth bass, Dworshak Reservoir, Idaho.

254 mm limit

1	B	C	D	E	F	G	H	I	J	K
2										
3										
4		Average	Initial					Total		
5	Age	Weight	Population	M	F	Z	S	Deaths	Catch	Yield
6		(kg)								(kg)
7			1000							
8	1	0.01		0.495	0	E8+F8	2.718282^-G8	D7-D9	(F8/G8)*I8	J8*C8
9			H8*D7							
10	2	0.048		0.495	0	E10+F10	2.718282^-G10	D9-D11	(F10/G10)*I10	J10*C10
11			H10*D9							
12	3	0.118		0.495	0	E12+F12	2.718282^-G12	D11-D13	(F12/G12)*I12	J12*C12
13			H12*D11							
14	4	0.217		0.346	0.346	E14+F14	2.718282^-G14	D13-D15	(F14/G14)*I14	J14*C14
15			H14*D13							
16	5	0.339		0.26	0.234	E16+F16	2.718282^-G16	D15-D17	(F16/G16)*I16	J16*C16
17			H16*D15							
18	6	0.477		0.261	0.234	E18+F18	2.718282^-G18	D17-D19	(F18/G18)*I18	J18*C18
19			H18*D17							
20	7	0.624		0.261	0.234	E20+F20	2.718282^-G20	D19-D21	(F20/G20)*I20	J20*C20
21			H20*D19							
22	8	0.775		0.261	0.234	E22+F22	2.718282^-G22	D21-D23	(F22/G22)*I22	J22*C22
23			H22*D21							
24	9+	0.925		0.261	0.234	E24+F24	2.718282^-G24	D23-D25	(F24/G24)*I24	J24*C24
25			H24*D23							
26										
27	Totals							@SUM(I24..I8)	@SUM(J24..J8)	@SUM(K24..K8)

305 mm limit

1	B	C	D	E	F	G	H	I	J	K
2										
3										
4		Average	Initial					Total		
5	Age	Weight	Population	M	F	Z	S	Deaths	Catch	Yield
6		(kg)								(kg)
7			1000							
8	1	0.01		0.495	0	E8+F8	2.718282^-G8	D7-D9	(F8/G8)*I8	J8*C8
9			H8*D7							
10	2	0.048		0.495	0	E10+F10	2.718282^-G10	D9-D11	(F10/G10)*I10	J10*C10
11			H10*D9							
12	3	0.118		0.495	0	E12+F12	2.718282^-G12	D11-D13	(F12/G12)*I12	J12*C12
13			H12*D11							
14	4	0.217		0.495	0	E14+F14	2.718282^-G14	D13-D15	(F14/G14)*I14	J14*C14
15			H14*D13							
16	5	0.339		0.261	0.234	E16+F16	2.718282^-G16	D15-D17	(F16/G16)*I16	J16*C16
17			H16*D15							
18	6	0.477		0.261	0.234	E18+F18	2.718282^-G18	D17-D19	(F18/G18)*I18	J18*C18
19			H18*D17							
20	7	0.624		0.261	0.234	E20+F20	2.718282^-G20	D19-D21	(F20/G20)*I20	J20*C20
21			H20*D19							
22	8	0.775		0.261	0.234	E22+F22	2.718282^-G22	D21-D23	(F22/G22)*I22	J22*C22
23			H22*D21							
24	9+	0.925		0.261	0.234	E24+F24	2.718282^-G24	D23-D25	(F24/G24)*I24	J24*C24
25			H24*D23							
26										
27	Totals							@SUM(I24..I8)	@SUM(J24..J8)	@SUM(K24..K8)

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/[3] strain	Length (mm)	Weight (gm)
08/02/88	Elk Cr. Arm	km	1.3	f	14.5	smb	177	59
08/02/88	Elk Cr. Arm	km	1.3	f		smb	170	54
08/16/88	Elk Cr. Arm	km	1.3	f	15.2	smb	107	12
08/16/88	Elk Cr. Arm	km	1.3	f		smb	171	52
08/16/88	Elk Cr. Arm	km	1.3	f		hrbrv	191	68
08/16/88	Elk Cr. Arm	km	1.3	s	15.0	smb	332	530
08/16/88	Elk Cr. Arm	km	1.3	s		smb	203	84
08/16/88	Elk Cr. Arm	km	1.3	s		smb	205	98
08/16/88	Elk Cr. Arm	km	1.3	s		smb	151	42
08/16/88	Elk Cr. Arm	km	1.3	s		smb	173	56
08/16/88	Elk Cr. Arm	km	1.3	s		smb	187	70
08/16/88	Elk Cr. Arm	km	1.3	s		hrblv	206	90
08/16/88	Elk Cr. Arm	km	1.3	s		cr	255	250
08/16/88	Elk Cr. Arm	km	1.3	s		sq	572	0
08/16/88	Elk Cr. Arm	km	1.3	s		sq	555	1520
08/16/88	Elk Cr. Arm	km	1.3	s		sq	247	130
08/16/88	Elk Cr. Arm	km	1.3	s		sq	312	220
08/16/88	Elk Cr. Arm	km	1.3	s		su	448	795
08/16/88	Elk Cr. Arm	km	1.3	s		su	372	510
08/16/88	Elk Cr. Arm	km	1.3	s		su	373	435
08/16/88	Elk Cr. Arm	km	1.3	s		su	384	510
08/16/88	Elk Cr. Arm	km	1.3	s		su	350	430
08/17/88	Elk Cr. Arm	km	5.0	f	15.5	smb	157	42
08/17/88	Elk Cr. Arm	km	5.0	s	15.5	smb	166	
08/17/88	Elk Cr. Arm	km	5.0	s		smb	221	112
08/17/88	Elk Cr. Arm	km	5.0	s		smb	317	475
08/17/88	Elk Cr. Arm	km	5.0	s		hrblv	214	96
08/17/88	Elk Cr. Arm	km	5.0	s		hrbu	199	
08/17/88	Elk Cr. Arm	km	5.0	s		sq	262	
08/17/88	Elk Cr. Arm	km	5.0	s		su	402	
08/17/88	Elk Cr. Arm	km	5.0	s		su	388	
08/17/88	Elk Cr. Arm	km	4.5	s	15.0	hrblv	90	76
08/17/88	Elk Cr. Arm	km	4.5	s		hrblv	212	99
08/17/88	Elk Cr. Arm	km	4.5	s		hrblv	225	93
08/17/88	Elk Cr. Arm	km	4.5	s		hrblv	193	66
08/17/88	Elk Cr. Arm	km	4.5	s		hrblv	202	66
08/17/88	Elk Cr. Arm	km	4.5	s		hrblv	196	68
08/17/88	Elk Cr. Arm	km	4.5	s		hrbu	213	90
08/17/88	Elk Cr. Arm	km	4.5	s		hrbu	212	100
08/17/88	Elk Cr. Arm	km	4.5	s		hrbu	208	78
08/17/88	Elk Cr. Arm	km	4.5	s		hrbu	209	68
08/17/88	Elk Cr. Arm	km	4.5	s		hrbu	220	90
08/17/88	Elk Cr. Arm	km	4.5	s		wrbt	213	86
08/17/88	Elk Cr. Arm	km	4.5	s		kok	211	94
08/17/88	Elk Cr. Arm	km	4.5	s		kok	212	87
08/17/88	Elk Cr. Arm	km	4.5	s		kok	294	205
08/17/88	Elk Cr. Arm	km	4.5	s		sq	370	
08/17/88	Elk Cr. Arm	km	4.5	s		sq	360	
08/17/88	Elk Cr. Arm	km	4.5	s		su	350	
08/30/88	Little N. Fk.	km	5.8	f	17.0	smb	182	
08/30/88	Little N. Fk.	km	5.8	f		smb	212	
08/30/88	Little N. Fk.	km	5.8	f		sq	310	
08/30/88	Little N. Fk.	km	5.8	f		sq	228	
08/30/88	Little N. Fk.	km	5.8	f		sq	275	
08/30/88	Little N. Fk.	km	5.8	f		sq	217	
08/30/88	Little N. Fk.	km	5.8	f		sq	265	
08/30/88	Little N. Fk.	km	5.8	f		sq	195	
08/30/88	Little N. Fk.	km	5.8	f		sq	270	
08/30/88	Little N. Fk.	km	5.8	f		sq	256	

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
08/30/88	Little N. Fk.	km	5.8	f		sq	268	
08/30/88	Little N. Fk.	km	5.8	f		sq	257	
08/30/88	Little N. Fk.	km	5.8	f		sq	257	
08/30/88	Little N. Fk.	km	5.8	f		sq	281	
08/30/88	Little N. Fk.	km	5.8	f		sq	200	
08/30/88	Little N. Fk.	km	5.8	f		su	370	
08/30/88	Little N. Fk.	km	5.8	f		su	375	
08/30/88	Little N. Fk.	km	5.8	f		su	440	
08/30/88	Little N. Fk.	km	5.8	f		su	420	
08/30/88	Little N. Fk.	km	5.8	f		su	295	
08/30/88	Little N. Fk.	km	5.8	f		su	401	
08/30/88	Little N. Fk.	km	5.6	s	14.7	bull	314	
08/30/88	Little N. Fk.	km	5.6	s		kok	301	
08/30/88	Little N. Fk.	km	5.6	s		kok	286	
08/30/88	Little N. Fk.	km	5.6	s		kok	289	
08/30/88	Little N. Fk.	km	5.6	s		kok	311	
08/30/88	Little N. Fk.	km	5.6	s		kok	323	
08/30/88	Little N. Fk.	km	5.6	s		kok	295	
08/30/88	Little N. Fk.	km	5.6	s		kok	297	
08/30/88	Little N. Fk.	km	5.6	s		kok	286	
08/30/88	Little N. Fk.	km	5.6	s		kok	292	
08/30/88	Little N. Fk.	km	5.6	s		kok	300	
08/30/88	Little N. Fk.	km	5.6	s		kok	334	
08/30/88	Little N. Fk.	km	5.6	s		kok	305	
08/30/88	Little N. Fk.	km	5.6	s		kok	283	
08/30/88	Little N. Fk.	km	5.6	s		kok	294	
08/30/88	Little N. Fk.	km	5.6	s		kok	304	
08/30/88	Little N. Fk.	km	5.6	s		kok	315	
08/30/88	Little N. Fk.	km	5.6	s		kok	302	
08/30/88	Little N. Fk.	km	5.6	s		sq	332	
08/30/88	Little N. Fk.	km	5.6	s		sq	395	
08/30/88	Little N. Fk.	km	5.6	s		sq	332	
08/30/88	Little N. Fk.	km	5.6	s		sq	500	
08/30/88	Little N. Fk.	km	5.6	s		sq	325	
08/30/88	Little N. Fk.	km	5.6	s		sq	231	
08/30/88	Little N. Fk.	km	5.6	s		sq	221	
08/30/88	Little N. Fk.	km	5.6	s		su	452	
08/30/88	Little N. Fk.	km	5.6	s		su	401	
08/30/88	Little N. Fk.	km	5.6	s		su	375	
08/30/88	Little N. Fk.	km	5.6	s		su	362	
08/30/88	Little N. Fk.	km	5.6	s		su	476	
08/30/88	Little N. Fk.	km	5.6	s		su	421	
08/30/88	Little N. Fk.	km	5.6	s		su	373	
08/30/88	Little N. Fk.	km	5.6	s		su	400	
08/30/88	Little N. Fk.	km	5.6	s		su	395	
08/30/88	Little N. Fk.	km	5.6	s		su	400	
08/30/88	Salmon Landing	km	83.7	f	15.0	kok	290	
08/30/88	Salmon Landing	km	83.7	f		smb	287	
08/30/88	Salmon Landing	km	83.7	f		smb	287	
08/30/88	Salmon Landing	km	83.7	f		smb	263	
08/30/88	Salmon Landing	km	83.7	f		smb	173	
08/30/88	Salmon Landing	km	83.7	f		smb	215	
08/30/88	Salmon Landing	km	83.7	f		smb	166	
08/30/88	Salmon Landing	km	83.7	f		smb	200	
08/30/88	Salmon Landing	km	83.7	f		smb	100	
08/30/88	Salmon Landing	km	83.7	f		smb	100	
08/30/88	Salmon Landing	km	83.7	f		smb	102	
08/30/88	Salmon Landing	km	83.7	f		smb	102	
08/30/88	Salmon Landing	km	83.7	f		smb	106	

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
08/30/88	Salmon Landing km 83.7	f		smb	156	
08/30/88	Salmon Landing km 83.7	f		smb	203	
08/30/88	Salmon Landing km 83.7	f		smb	105	
08/30/88	Salmon Landing km 83.7	f		smb	187	
08/30/88	Salmon Landing km 83.7	f		smb	106	
08/30/88	Salmon Landing km 83.7	f		smb	107	
08/30/88	Salmon Landing km 83.7	f		smb	100	
08/30/88	Salmon Landing km 83.7	f		smb	105	
08/30/88	Salmon Landing km 83.7	f		sq	497	
08/30/88	Salmon Landing km 83.7	f		sq	285	
08/30/88	Salmon Landing km 83.7	f		sq	382	
08/30/88	Salmon Landing km 83.7	f		sq	264	
08/30/88	Salmon Landing km 83.7	f		sq	277	
08/30/88	Salmon Landing km 83.7	f		sq	270	
08/30/88	Salmon Landing km 83.7	f		sq	262	
08/30/88	Salmon Landing km 83.7	f		sq	284	
08/30/88	Salmon Landing km 83.7	f		sq	235	
08/30/88	Salmon Landing km 83.7	f		sq	251	
08/30/88	Salmon Landing km 83.7	f		su	402	
08/30/88	Salmon Landing km 83.7	f		su	377	
08/30/88	Salmon Landing km 83.7	f		su	443	
08/30/88	Salmon Landing km 83.7	f		su	390	
08/30/88	Salmon Landing km 83.7	f		su	383	
08/30/88	Salmon Landing km 83.7	f		su	370	
08/30/88	Salmon Landing km 83.7	f		su	385	
08/30/88	Salmon Landing km 83.7	f		su	377	
08/30/88	Salmon Landing km 83.7	f		su	388	
08/30/88	Salmon Landing km 83.7	f		cm	350	
08/30/88	Salmon Landing km 83.7	s	13.8	hrbrv	228	120
08/30/88	Salmon Landing km 83.7	s		smb	327	410
08/30/88	Salmon Landing km 83.7	s		smb	323	390
08/30/88	Salmon Landing km 83.7	s		smb	195	92
08/30/88	Salmon Landing km 83.7	s		smb	187	88
08/30/88	Salmon Landing km 83.7	s		smb	166	60
08/30/88	Salmon Landing km 83.7	s		smb	167	60
08/30/88	Salmon Landing km 83.7	s		smb	100	14
08/30/88	Salmon Landing km 83.7	s		smb	114	16
08/30/88	Salmon Landing km 83.7	s		smb	96	14
08/30/88	Salmon Landing km 83.7	s		smb	112	14
08/30/88	Salmon Landing km 83.7	s		smb	107	14
08/30/88	Salmon Landing km 83.7	s		smb	104	12
08/30/88	Salmon Landing km 83.7	s		smb	107	
08/30/88	Salmon Landing km 83.7	s		smb	195	96
08/30/88	Salmon Landing km 83.7	s		wf	348	390
08/30/88	Salmon Landing km 83.7	s		wf	355	395
08/30/88	Salmon Landing km 83.7	s		wf	373	530
08/30/88	Salmon Landing km 83.7	s		wf	374	475
08/30/88	Salmon Landing km 83.7	s		wf	354	405
08/30/88	Salmon Landing km 83.7	s		wf	354	410
08/30/88	Salmon Landing km 83.7	s		wf	379	530
08/30/88	Salmon Landing km 83.7	s		sq	520	
08/30/88	Salmon Landing km 83.7	s		sq	330	
08/30/88	Salmon Landing km 83.7	s		sq	368	
08/30/88	Salmon Landing km 83.7	s		su	449	
08/30/88	Salmon Landing km 83.7	s		su	373	
08/30/88	Salmon Landing km 83.7	s		su	397	
08/30/88	Salmon Landing km 83.7	s		su	380	
08/30/88	Salmon Landing km 83.7	s		su	441	
08/30/88	Salmon Landing km 83.7	s		su	369	

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
08/30/88	Salmon Landing	km	83.7	s		su	377	
08/30/88	Salmon Landing	km	83.7	s		su	383	
08/30/88	Salmon Landing	km	83.7	s		su	370	
08/30/88	Salmon Landing	km	83.7	s		su	410	
08/30/88	Salmon Landing	km	83.7	s		su	382	
08/30/88	Salmon Landing	km	83.7	s		su	373	
08/30/88	Salmon Landing	km	83.7	s		su	424	
08/30/88	Salmon Landing	km	83.7	s		su	385	
08/31/88	Magnus Bay	km	43.4	f	16.0	hrblv	216	78
08/31/88	Magnus Bay	km	43.4	f		hrblv	216	90
08/31/88	Magnus Bay	km	43.4	f		smb	160	44
08/31/88	Magnus Bay	km	43.4	s	16.0	hrblv	218	98
08/31/88	Magnus Bay	km	43.4	s		smb	306	355
08/31/88	Magnus Bay	km	43.4	s		smb	161	44
08/31/88	Magnus Bay	km	43.4	s		sq	540	0
08/31/88	Magnus Bay	km	43.4	s		sq	447	
08/31/88	Magnus Bay	km	43.4	s		sq	312	
08/31/88	Magnus Bay	km	43.4	s		su	399	
08/31/88	Magnus Bay	km	43.4	s		su	350	
08/31/88	Reed's Cr. Arm	km	1.3	f	18.2	hrbu	210	90
08/31/88	Reed's Cr. Arm	km	1.3	f		hrbu	207	89
08/31/88	Reed's Cr. Arm	km	1.3	f		smb	333	585
08/31/88	Reed's Cr. Arm	km	1.3	f		sq	210	
08/31/88	Reed's Cr. Arm	km	1.3	f		sq	205	
08/31/88	Reed's Cr. Arm	km	1.3	s	18.2	hrblv	211	86
08/31/88	Reed's Cr. Arm	km	1.3	s		hrbrv	206	100
08/31/88	Reed's Cr. Arm	km	1.3	s		smb	158	46
08/31/88	Reed's Cr. Arm	km	1.3	s		smb	111	18
08/31/88	Reed's Cr. Arm	km	1.3	s		wf	269	
08/31/88	Reed's Cr. Arm	km	1.3	s		sq	259	
08/31/88	Reed's Cr. Arm	km	1.3	s		sq	270	
08/31/88	Reed's Cr. Arm	km	1.3	s		sq	267	
08/31/88	Reed's Cr. Arm	km	1.3	s		su	442	
08/31/88	Reed's Cr. Arm	km	1.3	s		su	400	
08/31/88	Reed's Cr. Arm	km	1.3	s		su	275	
08/31/88	Reed's Cr. Arm	km	1.3	s		su	240	
08/31/88	Reed's Cr. Arm	km	1.3	s		su	380	
09/30/88	Elk Cr. Arm	km	7.4	f	17.0	hrbrv	205	88
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	230	104
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	226	84
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	232	114
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	216	92
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	231	102
09/30/88	Elk Cr. Arm	km	7.4	f		hrblv	215	96
09/30/88	Elk Cr. Arm	km	7.4	f		smb	157	44
09/30/88	Elk Cr. Arm	km	7.4	f		smb	179	64
09/30/88	Elk Cr. Arm	km	7.4	s	16.8	hrblv	233	110
09/30/88	Elk Cr. Arm	km	7.4	s		hrblv	233	106
09/30/88	Elk Cr. Arm	km	7.4	s		hrblv	231	108
09/30/88	Elk Cr. Arm	km	7.4	s		hrblv	220	98
09/30/88	Elk Cr. Arm	km	7.4	s		hrblv	223	106
09/30/88	Elk Cr. Arm	km	7.4	s		smb	383	925
09/29/88	Elk Cr. Arm	km	1.3	f	16.8	hrblv	215	80
09/29/88	Elk Cr. Arm	km	1.3	f		hrblv	216	80
09/29/88	Elk Cr. Arm	km	1.3	f		hrblv	222	100
09/29/88	Elk Cr. Arm	km	1.3	f		hrblv	227	104
09/29/88	Elk Cr. Arm	km	1.3	f		hrblv	224	98
09/29/88	Elk Cr. Arm	km	1.3	f		hrblv	234	106
09/29/88	Elk Cr. Arm	km	1.3	f		hrbrv	219	98

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
09/29/88	Elk Cr. Arm	km	1.3	f		kok	235	118
09/29/88	Elk Cr. Arm	km	1.3	f		kok	289	185
09/29/88	Elk Cr. Arm	km	1.3	s	17.0	hrblv	255	130
09/29/88	Elk Cr. Arm	km	1.3	s		hrblv	240	112
09/29/88	Elk Cr. Arm	km	1.3	s		kok	297	220
09/29/88	Elk Cr. Arm	km	1.3	s		sq	592	
09/29/88	Elk Cr. Arm	km	1.3	s		su	445	
09/29/88	Elk Cr. Arm	km	1.3	s		su	419	
09/29/88	Elk Cr. Arm	km	1.3	s		su	380	
09/29/88	Elk Cr. Arm	km	1.3	s		su	450	
09/29/88	Elk Cr. Arm	km	1.3	s		su	416	
10/20/88	Freeman Cr.	km	12.9	f	18.0	hrblv	233	118
10/20/88	Freeman Cr.	km	12.9	f		hrblv	240	118
10/20/88	Freeman Cr.	km	12.9	f		hrblv	248	126
10/20/88	Freeman Cr.	km	12.9	f		hrblv	231	108
10/20/88	Freeman Cr.	km	12.9	f		hrblv	242	130
10/20/88	Freeman Cr.	km	12.9	f		hrblv	232	104
10/20/88	Freeman Cr.	km	12.9	f		hrblv	234	114
10/20/88	Freeman Cr.	km	12.9	f		hrblv	245	120
10/20/88	Freeman Cr.	km	12.9	f		hrblv	223	100
10/20/88	Freeman Cr.	km	12.9	f		hrblv	239	130
10/20/88	Freeman Cr.	km	12.9	f		hrblv	233	118
10/20/88	Freeman Cr.	km	12.9	f		hrblv	234	126
10/20/88	Freeman Cr.	km	12.9	f		hrblv	219	94
10/20/88	Freeman Cr.	km	12.9	f		hrblv	228	102
10/20/88	Freeman Cr.	km	12.9	f		hrblv	235	120
10/20/88	Freeman Cr.	km	12.9	f		hrblv	229	98
10/20/88	Freeman Cr.	km	12.9	f		hrblv	242	130
10/20/88	Freeman Cr.	km	12.9	f		hrblv	235	102
10/20/88	Freeman Cr.	km	12.9	f		hrbrv	223	112
10/20/88	Freeman Cr.	km	12.9	f		hrbrv	222	108
10/20/88	Freeman Cr.	km	12.9	s	18.2	hrblv	220	85
10/20/88	Freeman Cr.	km	12.9	s		hrblv	238	120
10/20/88	Freeman Cr.	km	12.9	s		hrbrv	220	108
10/20/88	Freeman Cr.	km	12.9	s		su	390	0
10/20/88	Freeman Cr.	km	12.9	s		su	422	0
10/20/88	Freeman Cr.	km	12.9	s		su	373	0
10/21/88	Canyon Cr.	km	11.3	f	17.2	hrblv	219	88
10/21/88	Canyon Cr.	km	11.3	f		hrblv	228	110
10/21/88	Canyon Cr.	km	11.3	f		hrblv	225	108
10/21/88	Canyon Cr.	km	11.3	f		hrblv	229	114
10/21/88	Canyon Cr.	km	11.3	f		hrblv	222	108
10/21/88	Canyon Cr.	km	11.3	f		hrblv	235	122
10/21/88	Canyon Cr.	km	11.3	f		hrblv	230	114
10/21/88	Canyon Cr.	km	11.3	f		hrblv	225	120
10/21/88	Canyon Cr.	km	11.3	f		hrblv	234	106
10/21/88	Canyon Cr.	km	11.3	f		hrblv	238	120
10/21/88	Canyon Cr.	km	11.3	f		sq	434	980
10/21/88	Canyon Cr.	km	11.3	s	17.2	su	434	
10/21/88	Canyon Cr.	km	11.3	s		su	425	
10/21/88	Canyon Cr.	km	11.3	s		su	467	
10/21/88	Canyon Cr.	km	11.3	s		su	442	
10/21/88	Canyon Cr.	km	11.3	s		su	416	
10/21/88	Canyon Cr.	km	11.3	s		su	430	
11/23/88	Merry's Bay	km	5.6	f	18.2	hrblv	223	102
11/23/88	Merry's Bay	km	5.6	f		hrblv	234	116
11/23/88	Merry's Bay	km	5.6	f		hrblv	221	95
11/23/88	Merry's Bay	km	5.6	f		hrblv	235	125
11/23/88	Merry's Bay	km	5.6	f		hrblv	232	117

Appendix C. Gill net field data, 1988, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/[3] strain	Length (mm)	Weight (gm)
11/23/88	Merry's Bay	km	5.6	f		hrblv	233	119
11/23/88	Merry's Bay	km	5.6	f		hrblv	240	114
11/23/88	Merry's Bay	km	5.6	f		hrblv	220	97
11/23/88	Merry's Bay	km	5.6	f		hrblv	240	125
11/23/88	Merry's Bay	km	5.6	f		hrblv	232	108
11/23/88	Merry's Bay	km	5.6	f		hrblv	234	110
11/23/88	Merry's Bay	km	5.6	f		hrblv	205	89
11/23/88	Merry's Bay	km	5.6	f		hrblv	227	102
11/23/88	Merry's Bay	km	5.6	f		hrbrv	232	112
11/23/88	Merry's Bay	km	5.6	f		hrbrv	227	106
11/23/88	Merry's Bay	km	5.6	f		hrbrv	240	123
11/23/88	Merry's Bay	km	5.6	f		hrbrv	234	109
11/23/88	Merry's Bay	km	5.6	f		hrbrv	246	135
11/23/88	Merry's Bay	km	5.6	f		hrbrv	239	125
11/23/88	Merry's Bay	km	5.6	f		hrbrv	228	108
11/23/88	Merry's Bay	km	5.6	f		hrbrv	233	119
11/23/88	Merry's Bay	km	5.6	f		kok	232	115
11/23/88	Merry's Bay	km	5.6	f		kok	241	121
11/23/88	Merry's Bay	km	5.6	s	18.9	hrblv	235	130
11/23/88	Merry's Bay	km	5.6	s		hrblv	225	94
11/23/88	Merry's Bay	km	5.6	s		su	434	
11/23/88	Merry's Bay	km	5.6	s		su	450	
11/22/88	Indian Cr.	km	9.5	f	19.5	hrblv	146	
11/22/88	Indian Cr.	km	9.5	f		hrblv	238	
11/22/88	Indian Cr.	km	9.5	f		hrbrv	244	
11/22/88	Indian Cr.	km	9.5	f		hrbrv	222	
11/22/88	Indian Cr.	km	9.5	f		su	385	
11/22/88	Indian Cr.	km	9.5	f		su	372	
11/22/88	Indian Cr.	km	9.5	s	19.8	su	389	
11/22/88	Indian Cr.	km	9.5	s		su	431	
11/22/88	Indian Cr.	km	9.5	s		su	436	
11/22/88	Indian Cr.	km	9.5	s		su	405	
11/22/88	Indian Cr.	km	9.5	s		su	458	
11/22/88	Indian Cr.	km	9.5	s		su	404	
11/22/88	Indian Cr.	km	9.5	s		su	410	
11/22/88	Indian Cr.	km	9.5	s		su	385	
12/22/88	Indian Cr.	km	9.5	f	18.4	su	416	632
12/22/88	Merry's Bay	km	5.6	f	19.2	hrblv	245	108
12/22/88	Merry's Bay	km	5.6	f		kok	243	122
12/23/88	Freeman Cr.	km	12.9	f	21.5	none		
12/23/88	Freeman Cr.	km	12.9	f	20.2	hrbrv	241	112

Appendix C. Gill net field data, 1989, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/[3] strain	Length (mm)	Weight (gm)
04/27/89	Magnus Bay km 43.4	s	15.8	su	370	495
04/27/89	Magnus Bay km 43.4	s		sq	377	490
04/27/89	Magnus Bay km 43.4	f	15.0	sq	500	1690
04/27/89	Magnus Bay km 43.4	f		sq	445	910
04/27/89	Magnus Bay km 43.4	f		sq	496	1530
04/27/89	Magnus Bay km 43.4	f		cut	302	260
04/27/89	Magnus Bay km 43.4	f		wrbt	230	96
04/27/89	Magnus Bay km 43.4	f		kok	223	86
04/27/89	Elk Cr. Arm km 1.3	s	12.5	kok	244	
04/27/89	Elk Cr. Arm km 1.3	s		sq		
04/27/89	Elk Cr. Arm km 1.3	s		su		
04/27/89	Elk Cr. Arm km 1.3	f	13.2	kok	235	
04/27/89	Elk Cr. Arm km 1.3	f		kok	228	
04/27/89	Elk Cr. Arm km 1.3	f		hrblv	250	
04/27/89	Elk Cr. Arm km 1.3	f		smb	380	
04/27/89	Elk Cr. Arm km 1.3	f		sq		
04/27/89	Elk Cr. Arm km 1.3	f		su		
04/28/89	Cranberry Cr. Arm km 0.6	f	12.5	cut	265	0
04/28/89	Cranberry Cr. Arm km 0.6	f		cut	268	
04/28/89	Cranberry Cr. Arm km 0.6	f		kok	227	
04/28/89	Cranberry Cr. Arm km 0.6	f		sq		
04/28/89	Cranberry Cr. Arm km 0.6	s	12.5	none		
04/29/89	Reed's Cr. Arm km 1.3	s	17.2	su	358	420
04/29/89	Reed's Cr. Arm km 1.3	s		su	436	710
04/29/89	Reed's Cr. Arm km 1.3	s		sq	520	1760
04/29/89	Reed's Cr. Arm km 1.3	f	16.4	blt	512	1590
04/29/89	Reed's Cr. Arm km 1.3	f		sq	510	1790
04/29/89	Reed's Cr. Arm km 1.3	f		su	425	880
04/29/89	Reed's Cr. Arm km 1.3	f		sq	360	400
04/29/89	Reed's Cr. Arm km 1.3	f		sq	251	130
05/31/89	Merry's Bay km 5.6	s	16.0	kok	249	
05/31/89	Merry's Bay km 5.6	s		kok	242	
05/31/89	Merry's Bay km 5.6	s		sq	386	
05/31/89	Merry's Bay km 5.6	f	15.8	su	482	
05/31/89	Merry's Bay km 5.6	f		su	433	
05/31/89	Merry's Bay km 5.6	f	15.8	hrblv	260	
05/31/89	Merry's Bay km 5.6	f		wrbt	281	
05/31/89	Merry's Bay km 5.6	s	16.0	kok	245	
05/31/89	Merry's Bay km 5.6	s		kok	218	
05/31/89	Merry's Bay km 5.6	s		kok	230	
05/31/89	Merry's Bay km 5.6	s		sq	383	
05/31/89	Merry's Bay km 5.6	s		sq	393	
06/01/89	Freeman Cr. km 12.9	f	13.8	kok	100	
06/01/89	Freeman Cr. km 12.9	f		kok	262	150
06/01/89	Freeman Cr. km 12.9	f		wrbt	229	82
06/01/89	Freeman Cr. km 12.9	f		smb	171	46
06/01/89	Freeman Cr. km 12.9	f		su	510	
06/01/89	Freeman Cr. km 12.9	f		su	447	
06/01/89	Freeman Cr. km 12.9	f		sq	387	
06/01/89	Freeman Cr. km 12.9	f		smb	357	595
06/01/89	Freeman Cr. km 12.9	s	13.6	su	394	
06/01/89	Freeman Cr. km 12.9	s		smb	148	35
07/10/89	Little N. Fk. Arm km 0.5	f	14.0	sq	387	
07/10/89	Little N. Fk. Arm km 0.5	f		sq	287	
07/10/89	Little N. Fk. Arm km 0.5	f		sq	235	
07/10/89	Little N. Fk. Arm km 0.5	f		sq	190	
07/10/89	Little N. Fk. Arm km 0.5	f		sq	222	
07/10/89	Little N. Fk. Arm km 0.5	f		sq	184	
07/10/89	Little N. Fk. Arm km 0.5	s	14.8	su	383	

Appendix C. Gill net field data, 1989, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/ strain[3]	Length (mm)	Weight (gm)
07/10/89	Little N. Fk. Arm	km	0.5	s		su	450	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	395	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	375	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	415	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	370	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	396	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	370	
07/10/89	Little N. Fk. Arm	km	0.5	s		su	225	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	279	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	250	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	225	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	222	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	221	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	270	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	222	
07/10/89	Little N. Fk. Arm	km	0.5	s		sq	180	
07/10/89	Little N. Fk. Arm	km	0.5	s		lvad	190	68
07/28/89	Elk Cr. Arm	km	2.4	s	14.0	sq	230	0
07/28/89	Elk Cr. Arm	km	2.4	s		smb	170	58
07/28/89	Elk Cr. Arm	km	2.4	s	14.0	sq	290	
07/28/89	Elk Cr. Arm	km	2.4	s		lvad	224	94
07/28/89	Elk Cr. Arm	km	2.4	s		smb	220	114
07/28/89	Elk Cr. Arm	km	2.4	f	14.0	sq	495	
07/28/89	Elk Cr. Arm	km	2.4	f		sq	405	
07/28/89	Elk Cr. Arm	km	2.4	f		sq	395	
08/16/89	Salmon Landing	km	83.7	s	15.0	su	420	
08/16/89	Salmon Landing	km	83.7	s		su	420	
08/16/89	Salmon Landing	km	83.7	s		su	340	
08/16/89	Salmon Landing	km	83.7	s		su	354	
08/16/89	Salmon Landing	km	83.7	s		su	450	
08/16/89	Salmon Landing	km	83.7	s		su	374	
08/16/89	Salmon Landing	km	83.7	s		su	395	
08/16/89	Salmon Landing	km	83.7	s		su	443	
08/16/89	Salmon Landing	km	83.7	s		su	380	
08/16/89	Salmon Landing	km	83.7	s		su	385	
08/16/89	Salmon Landing	km	83.7	s		su	380	
08/16/89	Salmon Landing	km	83.7	s		su	400	
08/16/89	Salmon Landing	km	83.7	s		su	457	
08/16/89	Salmon Landing	km	83.7	s		su	427	
08/16/89	Salmon Landing	km	83.7	s		su	375	
08/16/89	Salmon Landing	km	83.7	s		su	400	
08/16/89	Salmon Landing	km	83.7	s		su	445	
08/16/89	Salmon Landing	km	83.7	s		su	375	
08/16/89	Salmon Landing	km	83.7	s		su	477	
08/16/89	Salmon Landing	km	83.7	s		su	454	
08/16/89	Salmon Landing	km	83.7	s		su	405	
08/16/89	Salmon Landing	km	83.7	s		su	365	
08/16/89	Salmon Landing	km	83.7	s		su	435	
08/16/89	Salmon Landing	km	83.7	s		su	460	
08/16/89	Salmon Landing	km	83.7	s		su	392	
08/16/89	Salmon Landing	km	83.7	s		su	350	
08/16/89	Salmon Landing	km	83.7	s		su	356	
08/16/89	Salmon Landing	km	83.7	s		kok	300	270
08/16/89	Salmon Landing	km	83.7	s		cut	251	130
08/16/89	Salmon Landing	km	83.7	s		sq	271	
08/16/89	Salmon Landing	km	83.7	s		chis	230	104
08/16/89	Salmon Landing	km	83.7	s		chis	226	95
08/16/89	Salmon Landing	km	83.7	s		smb	330	475
08/16/89	Salmon Landing	km	83.7	s		smb	295	325

Appendix C. Gill net field data, 1989, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
08/16/89	Salmon Landing km 83.7	s		smb	172	70
08/16/89	Salmon Landing km 83.7	s		smb	200	102
08/16/89	Salmon Landing km 83.7	s		smb	240	185
08/16/89	Salmon Landing km 83.7	s		smb	222	150
08/16/89	Salmon Landing km 83.7	s		smb	178	70
08/16/89	Salmon Landing km 83.7	s		smb	175	72
08/16/89	Salmon Landing km 83.7	s		smb	195	100
08/16/89	Salmon Landing km 83.7	s		smb	185	84
08/16/89	Salmon Landing km 83.7	s		smb	170	70
08/16/89	Salmon Landing km 83.7	s		smb	165	62
08/16/89	Salmon Landing km 83.7	s		smb	147	48
08/16/89	Salmon Landing km 83.7	s		smb	173	74
08/16/89	Salmon Landing km 83.7	s		smb	160	54
08/16/89	Salmon Landing km 83.7	s		smb	143	42
08/16/89	Salmon Landing km 83.7	s		smb	146	44
08/16/89	Salmon Landing km 83.7	s		smb	161	60
08/16/89	Salmon Landing km 83.7	s		smb	162	72
08/16/89	Salmon Landing km 83.7	s		smb	180	80
08/16/89	Salmon Landing km 83.7	s		smb	141	40
08/16/89	Salmon Landing km 83.7	s		smb	152	48
08/16/89	Salmon Landing km 83.7	s		smb	151	44
08/16/89	Salmon Landing km 83.7	s		smb	150	54
08/16/89	Salmon Landing km 83.7	s		smb	145	44
08/16/89	Salmon Landing km 83.7	s		smb	152	46
08/16/89	Salmon Landing km 83.7	s		smb	141	36
08/16/89	Salmon Landing km 83.7	s		smb	148	50
08/16/89	Salmon Landing km 83.7	s		smb	156	52
08/16/89	Salmon Landing km 83.7	s		smb	151	40
08/16/89	Salmon Landing km 83.7	s		smb	150	42
08/16/89	Salmon Landing km 83.7	s		smb	139	36
08/16/89	Salmon Landing km 83.7	s		smb	147	40
08/16/89	Salmon Landing km 83.7	s		smb	164	62
08/16/89	Salmon Landing km 83.7	s		smb	150	44
08/16/89	Salmon Landing km 83.7	s		smb	166	64
08/16/89	Salmon Landing km 83.7	s		smb	145	42
08/16/89	Salmon Landing km 83.7	s		smb	140	38
08/16/89	Salmon Landing km 83.7	s		smb	152	40
08/16/89	Salmon Landing km 83.7	s		smb	164	64
08/16/89	Salmon Landing km 83.7	s		smb	140	34
08/16/89	Salmon Landing km 83.7	s		smb	130	28
08/16/89	Salmon Landing km 83.7	s		smb	144	40
08/16/89	Salmon Landing km 83.7	s		smb	160	54
08/16/89	Salmon Landing km 83.7	s		smb	155	52
08/16/89	Salmon Landing km 83.7	s		smb	152	44
08/16/89	Salmon Landing km 83.7	s		smb	149	44
08/16/89	Salmon Landing km 83.7	s		smb	86	10
08/16/89	Salmon Landing km 83.7	s		smb	85	9
08/16/89	Salmon Landing km 83.7	s		smb	90	12
08/16/89	Salmon Landing km 83.7	s		smb	87	8
08/16/89	Salmon Landing km 83.7	s		smb	91	10
08/16/89	Salmon Landing km 83.7	s		smb	89	12
08/16/89	Salmon Landing km 83.7	s		smb	88	10
08/16/89	Salmon Landing km 83.7	s		smb	84	10
08/16/89	Salmon Landing km 83.7	s		smb	83	10
08/16/89	Salmon Landing km 83.7	s		smb	82	8
08/16/89	Salmon Landing km 83.7	s		smb	80	8
08/16/89	Salmon Landing km 83.7	s		smb	79	6
08/16/89	Salmon Landing km 83.7	s		smb	85	10
08/16/89	Salmon Landing km 83.7	s		sq	344	

Appendix C. Gill net field data, 1989, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
08/16/89	Salmon Landing km 83.7	s		sq	222	
08/16/89	Salmon Landing km 83.7	s		sq	122	
08/16/89	Salmon Landing km 83.7	s		sq	137	
08/16/89	Salmon Landing km 83.7	s		sq	130	
08/16/89	Salmon Landing km 83.7	s		sq	207	
08/16/89	Salmon Landing km 83.7	s		sq	220	
08/16/89	Salmon Landing km 83.7	s		sq	208	
08/16/89	Salmon Landing km 83.7	s		sq	125	
08/16/89	Salmon Landing km 83.7	f	14.8	su	367	
08/16/89	Salmon Landing km 83.7	f		su	406	
08/16/89	Salmon Landing km 83.7	f		su	395	
08/16/89	Salmon Landing km 83.7	f		su	382	
08/16/89	Salmon Landing km 83.7	f		su	416	
08/16/89	Salmon Landing km 83.7	f		su	412	
08/16/89	Salmon Landing km 83.7	f		su	380	
08/16/89	Salmon Landing km 83.7	f		su	382	
08/16/89	Salmon Landing km 83.7	f		su	455	
08/16/89	Salmon Landing km 83.7	f		su	384	
08/16/89	Salmon Landing km 83.7	f		su	457	
08/16/89	Salmon Landing km 83.7	f		su	370	
08/16/89	Salmon Landing km 83.7	f		su	374	
08/16/89	Salmon Landing km 83.7	f		su	377	
08/16/89	Salmon Landing km 83.7	f		sq	247	
08/16/89	Salmon Landing km 83.7	f		sq	227	
08/16/89	Salmon Landing km 83.7	f		sq	240	
08/16/89	Salmon Landing km 83.7	f		sq	212	
08/16/89	Salmon Landing km 83.7	f		sq	210	
08/16/89	Salmon Landing km 83.7	f		sq	224	
08/16/89	Salmon Landing km 83.7	f		sq	215	
08/16/89	Salmon Landing km 83.7	f		sq	280	
08/16/89	Salmon Landing km 83.7	f		sq	182	
08/16/89	Salmon Landing km 83.7	f		sq	225	
08/16/89	Salmon Landing km 83.7	f		sq	219	
08/16/89	Salmon Landing km 83.7	f		sq	171	
08/16/89	Salmon Landing km 83.7	f		sq	124	
08/16/89	Salmon Landing km 83.7	f		sq	115	
08/16/89	Salmon Landing km 83.7	f		sq	118	
08/16/89	Salmon Landing km 83.7	f		sq	127	
08/16/89	Salmon Landing km 83.7	f		sq	115	
08/16/89	Salmon Landing km 83.7	f		sq	130	
08/16/89	Salmon Landing km 83.7	f		sq	115	
08/16/89	Salmon Landing km 83.7	f		kok	272	195
08/16/89	Salmon Landing km 83.7	f		smb	90	
08/16/89	Salmon Landing km 83.7	f		smb	91	
08/16/89	Salmon Landing km 83.7	f		smb	88	
08/16/89	Salmon Landing km 83.7	f		smb	85	
08/16/89	Salmon Landing km 83.7	f		smb	86	
08/16/89	Salmon Landing km 83.7	f		smb	87	
08/16/89	Salmon Landing km 83.7	f		smb	89	

Appendix C. Gill net field data, 1990, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/[3] strain	Length (mm)	Weight (gm)
06/26/90	Salmon Landing km 83.7	f	11.8	rss	118	
06/26/90	Salmon Landing km 83.7	f		rss	126	
06/26/90	Salmon Landing km 83.7	f		rss	105	
06/26/90	Salmon Landing km 83.7	f		rss	101	
06/26/90	Salmon Landing km 83.7	f		rss	101	
06/26/90	Salmon Landing km 83.7	f		rss	97	
06/26/90	Salmon Landing km 83.7	f		rss	109	
06/26/90	Salmon Landing km 83.7	f		rss	111	
06/26/90	Salmon Landing km 83.7	f		su	415	
06/26/90	Salmon Landing km 83.7	f		sq	120	
06/26/90	Salmon Landing km 83.7	f		sq	123	
06/26/90	Salmon Landing km 83.7	f		sq	125	
06/26/90	Salmon Landing km 83.7	f		sq	145	
06/26/90	Salmon Landing km 83.7	f		sq	143	
06/26/90	Salmon Landing km 83.7	f		sq	131	
06/26/90	Salmon Landing km 83.7	f		sq	243	
06/26/90	Salmon Landing km 83.7	f		sq	278	
06/26/90	Salmon Landing km 83.7	f		sq	315	
06/26/90	Salmon Landing km 83.7	f		sq	323	
06/26/90	Salmon Landing km 83.7	f		sq	343	
06/26/90	Salmon Landing km 83.7	f		sq	390	
06/26/90	Salmon Landing km 83.7	s	11.8	cb	199	
06/26/90	Salmon Landing km 83.7	s		cb	95	
06/26/90	Salmon Landing km 83.7	s		su	368	
06/26/90	Salmon Landing km 83.7	s		su	421	
06/26/90	Salmon Landing km 83.7	s		su	395	
06/26/90	Salmon Landing km 83.7	s		su	430	
06/26/90	Salmon Landing km 83.7	s		su	445	
06/26/90	Salmon Landing km 83.7	s		su	457	
06/26/90	Salmon Landing km 83.7	s		sq	124	
06/26/90	Salmon Landing km 83.7	s		sq	111	
06/26/90	Salmon Landing km 83.7	s		sq	120	
06/26/90	Salmon Landing km 83.7	s		sq	117	
06/26/90	Salmon Landing km 83.7	s		sq	246	
06/26/90	Salmon Landing km 83.7	s		sq	264	
06/26/90	Salmon Landing km 83.7	s		sq	234	
06/26/90	Salmon Landing km 83.7	s		sq	306	
06/26/90	Salmon Landing km 83.7	s		sq	324	
06/26/90	Salmon Landing km 83.7	s		sq	320	
06/26/90	Salmon Landing km 83.7	s		sq	396	
06/27/90	Evans Cr. km 45.7	f	12.8	hrb90	179	
06/27/90	Evans Cr. km 45.7	f		su	414	
06/27/90	Evans Cr. km 45.7	f		su	376	
06/27/90	Evans Cr. km 45.7	f		su	378	
06/27/90	Evans Cr. km 45.7	f		su	411	
06/27/90	Evans Cr. km 45.7	f		su	453	
06/27/90	Evans Cr. km 45.7	f		su	387	
06/27/90	Evans Cr. km 45.7	f		su	455	
06/27/90	Evans Cr. km 45.7	f		su	397	
06/27/90	Evans Cr. km 45.7	f		su	371	
06/27/90	Evans Cr. km 45.7	f		su	432	
06/27/90	Evans Cr. km 45.7	f		su	440	
06/27/90	Evans Cr. km 45.7	f		su	461	
06/27/90	Evans Cr. km 45.7	f		su	440	
06/27/90	Evans Cr. km 45.7	f		su	420	
06/27/90	Evans Cr. km 45.7	f		su	449	
06/27/90	Evans Cr. km 45.7	f		sq	135	
06/27/90	Evans Cr. km 45.7	f		sq	130	
06/27/90	Evans Cr. km 45.7	f		sq	110	

Appendix C. Gill net field data, 1990, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/strain[3]	Length (mm)	Weight (gm)
06/27/90	Evans Cr. km 45.7	f		sq	140	
06/27/90	Evans Cr. km 45.7	s	12.8	smb	230	150
06/27/90	Evans Cr. km 45.7	s		smb	230	135
06/27/90	Evans Cr. km 45.7	s		hrb90	181	
06/27/90	Evans Cr. km 45.7	s		hrb90	168	
06/27/90	Evans Cr. km 45.7	s		su	433	
06/27/90	Evans Cr. km 45.7	s		su	431	
06/27/90	Evans Cr. km 45.7	s		su	413	
06/27/90	Evans Cr. km 45.7	s		su	396	
06/27/90	Evans Cr. km 45.7	s		su	367	
06/27/90	Evans Cr. km 45.7	s		su	380	
06/27/90	Evans Cr. km 45.7	s		su	390	
06/27/90	Evans Cr. km 45.7	s		su	370	
06/27/90	Evans Cr. km 45.7	s		su	434	
06/27/90	Evans Cr. km 45.7	s		su	385	
06/27/90	Evans Cr. km 45.7	s		su	443	
06/27/90	Evans Cr. km 45.7	s		su	384	
06/27/90	Evans Cr. km 45.7	s		su	405	
06/27/90	Evans Cr. km 45.7	s		su	355	
06/27/90	Evans Cr. km 45.7	s		sq	242	
06/27/90	Evans Cr. km 45.7	s		sq	323	
06/27/90	Evans Cr. km 45.7	s		sq	237	
08/29/90	Indian Cr. km 9.5	f	13.3	none		
08/29/90	Indian Cr. km 9.5	f	13.5	none		
08/29/90	Indian Cr. km 9.5	s	13.4	smb	157	46
08/29/90	Indian Cr. km 9.5	s		smb	203	94
08/29/90	Indian Cr. km 9.5	s		smb	224	122
08/29/90	Indian Cr. km 9.5	s		smb	143	34
08/29/90	Indian Cr. km 9.5	s		smb	159	50
08/29/90	Indian Cr. km 9.5	s		smb	158	50
08/29/90	Indian Cr. km 9.5	s		hrb90	217	102
09/06/90	Elk Cr. Arm km 4.0	f	14.6	smb	164	50
09/06/90	Elk Cr. Arm km 4.0	f		smb	220	124
09/06/90	Elk Cr. Arm km 4.0	f		smb	245	170
09/06/90	Elk Cr. Arm km 4.2	s	15.8	smb	366	595
09/06/90	Elk Cr. Arm km 4.2	s		smb	161	50
09/06/90	Elk Cr. Arm km 4.2	s		su	407	
09/06/90	Elk Cr. Arm km 4.2	s		su	372	
09/06/90	Elk Cr. Arm km 4.2	s		su	395	
09/06/90	Elk Cr. Arm km 4.2	s		su	388	
09/06/90	Elk Cr. Arm km 4.2	s		su	450	
09/06/90	Elk Cr. Arm km 4.2	s		su	385	
09/06/90	Elk Cr. Arm km 4.2	s		sq	515	
09/06/90	Elk Cr. Arm km 4.2	s		sq	520	
09/06/90	Elk Cr. Arm km 4.2	s		sq	323	
09/06/90	Elk Cr. Arm km 4.2	s		kok	306	280
09/06/90	Elk Cr. Arm km 4.2	s		kok	306	280
09/06/90	Elk Cr. Arm km 4.2	s		kok	350	315
09/06/90	Elk Cr. Arm km 4.2	s		kok	320	295
09/06/90	Elk Cr. Arm km 4.2	s		kok	326	300
09/06/90	Elk Cr. Arm km 4.2	s		kok	311	291
09/06/90	Elk Cr. Arm km 4.2	s		kok	303	282
09/06/90	Elk Cr. Arm km 4.2	s		kok	300	280
09/06/90	Elk Cr. Arm km 4.2	s		kok	311	285
09/06/90	Elk Cr. Arm km 4.2	s		kok	311	293
09/06/90	Elk Cr. Arm km 4.2	s		kok	302	275
09/06/90	Elk Cr. Arm km 4.2	s		kok	323	295
09/06/90	Elk Cr. Arm km 4.2	s		kok	314	289
09/06/90	Elk Cr. Arm km 4.2	s		kok	302	278

Appendix C. Gill net field data, 1990, Dworshak Reservoir, Idaho.

Date	Location			Net type[1]	Net-hours[2]	Species/ strain[3]	Length (mm)	Weight (gm)
09/06/90	Elk Cr. Arm	km	4.2	s		kok	326	303
09/06/90	Elk Cr. Arm	km	4.2	f	15.6	none		
09/06/90	Elk Cr. Arm	km	4.0	s	14.3	smb	460	1560
09/06/90	Elk Cr. Arm	km	4.0	s		smb	421	1130
09/06/90	Elk Cr. Arm	km	4.0	s		ps	115	38
09/06/90	Elk Cr. Arm	km	4.0	s		cr	259	245
09/06/90	Elk Cr. Arm	km	4.0	s		bh		
09/06/90	Elk Cr. Arm	km	4.0	s		smb	160	53
09/06/90	Elk Cr. Arm	km	4.0	s		hrb90	233	124
09/06/90	Elk Cr. Arm	km	4.0	s		su	407	
09/06/90	Elk Cr. Arm	km	4.0	s		su	420	
09/06/90	Elk Cr. Arm	km	4.0	s		sq	372	
09/06/90	Elk Cr. Arm	km	4.0	s		sq	234	
09/06/90	Elk Cr. Arm	km	4.0	s		sq	369	
09/05/90	Elk Cr. Arm	km	1.1	f	14.7	none		
09/05/90	Elk Cr. Arm	km	1.1	s	15.0	smb	355	610
09/05/90	Elk Cr. Arm	km	1.1	s		smb	250	163
09/05/90	Elk Cr. Arm	km	1.1	s		kok	245	
09/05/90	Elk Cr. Arm	km	1.1	s		kok	314	
09/05/90	Elk Cr. Arm	km	1.1	s		kok	322	
09/05/90	Elk Cr. Arm	km	1.1	s		kok	328	
09/05/90	Elk Cr. Arm	km	1.1	s		kok	305	
09/05/90	Elk Cr. Arm	km	1.1	s		kok	320	
09/05/90	Elk Cr. Arm	km	1.1	s		su	440	
09/05/90	Elk Cr. Arm	km	1.1	s		su	416	
09/05/90	Elk Cr. Arm	km	1.1	s		su	436	
09/05/90	Elk Cr. Arm	km	1.1	s		su	483	
09/05/90	Elk Cr. Arm	km	1.1	s		su	450	
09/05/90	Elk Cr. Arm	km	1.1	s		su	448	
09/05/90	Elk Cr. Arm	km	1.1	s		su	403	
09/05/90	Elk Cr. Arm	km	1.1	s		su	383	
09/05/90	Elk Cr. Arm	km	1.1	s		su	415	
09/05/90	Elk Cr. Arm	km	1.1	s		su	440	
09/05/90	Elk Cr. Arm	km	1.1	s		sq	290	
09/05/90	Elk Cr. Arm	km	1.1	s		sq	305	
09/05/90	Elk Cr. Arm	km	1.1	s		sq	345	
09/05/90	Elk Cr. Arm	km	1.1	s		sq	350	
09/05/90	Elk Cr. Arm	km	1.3	f	13.6	smb	395	1150
09/05/90	Elk Cr. Arm	km	1.3	f		smb	211	118
09/05/90	Elk Cr. Arm	km	1.3	f		smb	157	46
09/05/90	Elk Cr. Arm	km	1.3	f		smb	226	135
09/05/90	Elk Cr. Arm	km	1.3	f		smb	143	34
09/05/90	Elk Cr. Arm	km	1.3	f		smb	159	48
09/05/90	Elk Cr. Arm	km	1.3	f		su	435	
09/05/90	Elk Cr. Arm	km	1.3	s	14.0	smb	93	11
09/05/90	Elk Cr. Arm	km	1.3	s		smb	229	140
09/05/90	Elk Cr. Arm	km	1.3	s		lvad	346	395
09/05/90	Elk Cr. Arm	km	1.3	s		kok	316	325
09/05/90	Elk Cr. Arm	km	1.3	s		kok	321	315
09/05/90	Elk Cr. Arm	km	1.3	s		kok	330	
09/05/90	Elk Cr. Arm	km	1.3	s		kok	320	
09/05/90	Elk Cr. Arm	km	1.3	s		kok	321	
09/05/90	Elk Cr. Arm	km	1.3	s		kok	326	
09/05/90	Elk Cr. Arm	km	1.3	s		kok	308	
09/05/90	Elk Cr. Arm	km	1.3	s		kok	306	
09/05/90	Elk Cr. Arm	km	1.3	s		su	411	
09/05/90	Elk Cr. Arm	km	1.3	s		su	443	
09/05/90	Elk Cr. Arm	km	1.3	s		su	390	
09/05/90	Elk Cr. Arm	km	1.3	s		su	395	

Appendix C. Gill net field data, 1990, Dworshak Reservoir, Idaho.

Date	Location	Net type[1]	Net-hours[2]	Species/[3] strain	Length (mm)	Weight (gm)
09/05/90	Elk Cr. Arm km 1.3	s		su	256	
09/05/90	Elk Cr. Arm km 1.3	s		su	470	
09/05/90	Elk Cr. Arm km 1.3	s		su	441	
09/05/90	Elk Cr. Arm km 1.3	s		su	449	
09/05/90	Elk Cr. Arm km 1.3	s		sq	498	1350
09/05/90	Elk Cr. Arm km 1.3	s		sq	419	

1 Floating and sinking horizontal experimental gill nets are indicated as "f" and "s," respectively.

2 Net-hours per individual net placement are shown at the beginning of the data set.

3 Abbreviations for species and rainbow trout strains are as follows:

bh	brown bullhead
blt	bull trout
cb	cutthroat trout-rainbow trout hybrid
chis	chiselmouth
cr	black crappie
cut	cutthroat trout
hrb90	rainbow trout released in 1990
hrblv	Shasta rainbow trout released in 1988
hrbrv	Arlee rainbow trout released in 1988
hrbu	unidentified hatchery rainbow trout
kok	kokanee
lvad	Shasta rainbow trout released in 1989
ps	pumpkinseed
rss	redside shiner
smb	smallmouth bass
sq	northern squawfish
su	sucker
wf	mountain whitefish
wrbt	wild/natural rainbow trout.

Appendix D. Diet rankings for Coefficient of Importance (C.I.) and percent by volume with associated values for Shasta and Arlee strain rainbow trout stomach samples (n = 23) collected in Dworshak Reservoir, Idaho, during 1988.

Trout strain	Taxa	Percent frequency	Percent by number	C.I.	Percent by volume	Rank: C.I.	Rank: Percent by volume
Shasta							
	Cladocera	10.6	81.4	29.4	8.9	1	5
	Hymenoptera	14.9	6.6	9.9	19.1	2	3
	Homoptera	12.8	4.8	7.9	9.5	3	4
	Hemiptera	17.0	1.7	5.4	19.6	4	2
	Diptera	17.0	1.3	4.6	1.4	5	7
	Coleoptera	12.8	1.6	4.5	8.9	6	5
	Physa	2.1	1.3	1.6	27.1	7	1
	Odanata	4.2	0.1	0.7	3.9	8	6
	Ehpemeroptera	0	0	0	0	9	8
Arlee							
	Cladocera	13.3	78.1	32.2	26.7	1	2
	Homoptera	10.0	11.7	10.8	14.2	2	3
	Hymenoptera	13.3	6.7	9.4	32.3	3	1
	Diptera	26.7	1.1	5.4	3.8	4	6
	Hemiptera	10.0	0.9	2.9	5.4	5	5
	Coleoptera	6.7	0.4	1.6	2.0	6	7
	Ephemeroptera	3.3	0.6	1.4	6.1	7	4
	Odonata	0	0	0	0	8	8
	Physa	0	0	0	0	9	8
Shasta and Arlee							
	Cladocera	11.7	79.4	30.5	13.0	1	4
	Homoptera	11.7	9.0	10.3	11.4	2	5
	Hymenoptera	14.3	6.7	9.8	24.3	3	1
	Diptera	20.8	1.2	4.9	2.1	4	9
	Hemiptera	14.3	1.2	4.1	15.0	5	3
	Coleoptera	10.4	0.9	3.0	6.7	6	6
	Physa	1.3	0.5	0.8	18.1	7	2
	Ephemeroptera	1.3	0.4	0.7	2.2	8	8
	Odonata	2.6	0.1	0.4	2.6	9	7

Appendix E. Diet rankings for Coefficient of Importance (C.I.) and percent by volume with associated values for smallmouth bass stomach samples collected in Dworshak Reservoir, Idaho, during 1988 and 1989.

Year	Taxa	Percent frequency	Percent by number	C.I.	Percent by volume	Rank C.I.	Rank Percent by volume
1988 (n = 20)	Hymenoptera	23.8	65.9	39.6	31.9	1	2
	Diptera	16.6	10.6	13.3	1.7	2	7
	Trichoptera	11.9	13.6	12.7	4.7	3	4
	Fish	19.0	3.5	8.2	44.3	4	1
	Ephemeroptera	7.1	1.6	3.4	3.1	5	6
	Coleoptera	7.1	1.1	2.8	3.3	6	5
	Homoptera	7.1	.8	2.4	0.4	7	8
	Cladocera	2.4	2.2	2.3	.1	8	9
	Ostracoda	4.8	.5	1.6	.1	9	9
	Hemiptera	0	0	0	0	10	10
	Decapoda	0	0	0	0	10	10
	Odonata	0	0	0	0	10	10
	Lepidoptera	0	0	0	0	10	10
	Plecoptera	0	0	0	0	10	10
	Aranae	0	0	0	0	10	10
	Miscellaneous	40.0	0	0	10.3	10	3
1989 (n = 52)	Ephemeroptera	42.3	54.6	48.1	11.4	1	2
	Fish	61.5	16.8	32.1	71.1	2	1
	Hemiptera	34.6	8.4	17.0	1.0	3	5
	Diptera	23.1	5.8	11.6	1.0	4	5
	Homoptera	9.6	4.9	6.9	2.0	5	4
	Coleoptera	9.6	2.6	5.0	1.0	6	5
	Decapoda	7.7	1.4	3.3	9.3	7	3
	Plecoptera	5.8	0.9	2.3	0.7	8	7
	Aranae	5.8	0.9	2.3	0.7	8	7
	Lepidoptera	1.9	1.7	1.8	0.8	9	6
	Trichoptera	3.8	0.6	1.5	0.1	10	10
	Hymenoptera	3.8	0.6	1.5	0.1	10	10
	Miscellaneous	1.9	0.6	1.5	0.2	10	9
	Odonata	1.9	0.3	0.8	0.4	11	8
	Ostracoda	0	0	0	0	12	11
	Cladocera	0	0	0	0	12	11

Appendix F. Phosphorus at river kilometer five in Dworshak Reservoir, Idaho.

	Total phosphorus as P (mg/L)	Ortho phosphate as P (mg/L)	Dissolved ortho phosphate as P (mg/L)	
1987			Lab	Field
Nov 16	--	--	0.001	--
Dec 14	--	--	<0.001	--
1988				
Jan 14	--	0.003	--	--
Feb 18	--	0.002	--	--
Mar 18	--	0.001	--	--
Apr 14	--	0.001	--	--
May 13	--	0.004	--	--
Jun 20	--	0.002	--	--
Jul 20	--	0.001	--	--
Aug 17	<0.050	0.001	--	--
Sep 14	<0.050	<0.001	--	--
Oct 13	<0.050	<0.001	--	--
Nov 18	<0.050	0.001	--	--
Dec 16	<0.050	0.002		
1989				
Jan 17	<0.050	0.003	--	--
Feb 14	<0.050	<0.010	--	--
Mar 16	<0.050	--	--	--
Apr 19	<0.050	--	--	--
May 10	<0.050	--	0.003	--
Jun 16	<0.050	<0.001	--	0.004
Jul 21	<0.050	<0.001	<0.001	--
Aug 21	<0.050	--	<0.001	<0.001
Sep 21	<0.050	--	--	<0.001
Nov 27	0.020	--	0.007	--

Appendix F. Continued.

	Unfiltered total phosphorus as P (mg/L)	Dissolved total phosphorus as P (mg/L)	Dissolved ortho phosphate as P (mg/L)
1990			
Feb 26	0.013	0.009	0.002
Mar 26	0.009	0.003	0.003
Apr 16	0.010	0.006	0.002
May 21	0.010	0.003	0.001
Jun 11	0.015	0.014	0.001
Jul 9	0.009	0.004	0.001
Aug 13	0.005	0.002	<0.002
Sep 17	0.010	0.004	<0.001
Oct 15	0.006	0.004	0.002
Nov 19	0.004	0.003	0.002

Phosphorus at Elk Creek site in Dworshak Reservoir, Idaho.

	Total phosphorus as P (mg/L)	Dissolved total phosphorus as P (mg/L)	Dissolved ortho phosphate as P (mg/L)
1990			
Mar 26	0.009	0.006	0.002
Apr 16	0.024	0.015	--
May 21	0.017	0.008	0.003
Jun 11	0.016	0.006	0.001
Jul 9	0.012	0.006	0.001
Aug 13	0.006	0.002	<0.002
Sep 17	0.008	0.007	0.001
Oct 15	0.011	0.007	<0.002
Nov 19	0.009	0.007	<0.002

Appendix G. Census information for anglers seeking kokanee on Dworshak Reservoir in 1990.

	Effort (hours) per reservoir section			
Month	I	II	III	Total
Jan	--	--	--	--
Feb	201	--	--	201
Mar	6,143	--	--	6,143
Apr	5,830	--	--	5,830
May	22,452	2,749	7	25,208
Jun	19,488	13,977	5,343	38,809
Jul	14,360	8,521	4,759	27,640
Aug	2,732	4,219	1,652	8,603
Sep	537	131	10	678
Oct	139	--	--	139
Nov	46	--	--	46
Dec	--	--	--	--
Total	71,928	29,597	11,772	113,297

	Catch rate per reservoir section			
Month	I	II	III	Mean
Jan	--	--	--	--
Feb	0.42	--	--	0.42
Mar	1.18	--	--	1.18
Apr	0.47	--	--	0.47
May	1.23	--	--	1.23
Jun	1.09	0.48	0.57	0.80
Jul	0.96	0.68	0.78	0.84
Aug	0.19	0.37	0.28	0.30
Sep	0.18	0.11	--	0.16
Oct	0.90	--	--	0.90
Nov	--	--	--	--
Dec	--	--	--	--
Mean	1.02	0.48	0.61	0.84

Appendix G. Continued.

Month	Harvest per reservoir section I	II	III	Total
Jan	--	--	--	--
Feb	85	--	--	85
Mar	7,249	--	--	7,249
Apr	2,740	--	--	2,740
May	27,616	--	--	27,616
Jun	21,242	6,709	3,045	30,997
Jul	13,785	5,794	3,712	23,292
Aug	519	1,561	463	2,543
Sep	97	14	--	111
Oct	125	--	--	125
Nov	--	--	--	--
Dec	--	--	--	--
Total	73,458	14,079	7,220	94,757

Appendix H. Chlorophyll a, total phosphorus, and sportfish harvest for bodies of water in Missouri, Iowa, and Idaho.

Body of water	Chlorophyll A (ug/L)	Total phosphorus (ug/L)	Sportfish harvest (kg/ha)
	Missouri		
Binder	27.2	56	107
Blind Pony	22.3	50	51
Deer Ridge	17.6	45	19
Henry Seaver	8.3	22	16
Hunnewell	14.7	34	37
Gravois Arm	10.3	22	13
Niangua Arm	14.3	31	31
Little Dixie	13.1	31	44
Little Prairie	12.5	25	91
Paho	11.5	52	44
Pony Express	29.2	67	104
James River Arm	26.1	55	25
Long Creek Arm	3.9	15	4
Thomas Hill	12.0	46	14
	Iowa		
Anita	35.1	38	81
Beeds	60.4	45	3
Big Creek	12.6	29	32
Clear	18.4	38	27
Cold Springs	66.7	65	212
Green Valley	67.7	76	159
Kent	39.7	74	105
McBride	32.5	59	97
Miami	42.6	57	126
Prairie Rose	57.9	90	137
Spirit	27.9	46	82
Viking	37.1	37	88
	Idaho		
Alturas	--	9	.02
Anderson Ranch	4.2	14	4.3
Coeur d'Alene	4.0	45	3.2
Dworshak (1990)	1.6	10.4	2.3
Dworshak (1991)	1.1	--	2.9
Payette	1.0	6	.1
Pend Oreille	2.0	11	2.6
Priest	1.5	4	1.2
Spirit	5.3	18	12.7

Appendix H. Continued.

Body of water	Chlorophyll A (ug/L)	Total phosphorus (ug/L)	Sportfish harvest (kg/ha)
	Other		
Banks	2.6	49	2.5
Billy Clapp	--	33	2.2
Chelan	.7	3	.1
Deer	--	30	.9
Loon	--	30	.7
Sammamish	3.4	21	.1
Arrow	.8	4	.1
Kootenay	1.5	6	.1
Okanagan	1.6	10	.8
Flathead	--	5	2.6
Libby/Koocanusa	3.0	17	8.6
Flaming Gorge	4.2	30	1.1
Odell	2.9	--	10.1
Wallowa	1.9	--	4.5

Note: All Idaho and Other waters are kokanee harvest only.

Appendix I. Secchi depths on Dworshak Reservoir, Idaho.

	RK5	EC6	RK31	RK56	RK70	LNF2
1987						
Nov 15	7.1	5.9	6.8	--	--	--
Dec 14-18	5.9	4.1	4.3	3.1	3.4	2.8
1988						
Jan 13-17	3.9	1.7	4.2	2.2	--	--
Feb 16	4.8	0.9	4.1	--	--	--
Mar 16-17	6.1	3.4	4.9	2.1	--	--
Apr 13-14	2.1	1.6	2.4	2.3	--	1.9
May 13-14	2.3	1.2	1.5	1.9	--	3.9
Jun 28-29	3.7	2.6	2.6	3.1	--	4.8
Jul 18-19	4.4	2.5	3.5	4.8	--	4.6
Aug 15-16	3.8	2.6	4.4	6.5	--	5.0
Sep 13-14	5.3	3.7	5.0	3.7	--	3.8
Oct 11-12	4.1	3.8	4.9	5.8	--	5.7
Nov 16-17	5.6	3.3	5.3	4.0	--	3.7
Dec 15	5.0	3.0	4.4	4.9	--	--
1989						
Jan 14-17	4.9	4.0	4.7	--	--	--
Feb 13	2.85	2.9	--	--	--	--
Mar 15	3.5	0.6	2.1	--	--	--
Apr 17-18	--	1.2	1.4	1.8	--	1.1
May 9	2.3	1.8	2.3	3.0	2.3	2.2
Jun 15-16	3.0	3.2	3.7	3.0	2.9	3.6
Jul 17	5.9	3.2	7.2	8.7	6.0	7.0
Aug 15-16	4.17	3.5	5.0	5.3	5.0	4.9
Sep 14-19	3.9	3.7	5.9	4.8	5.6	5.1
Oct 22-23	6.0	6.1	6.0	5.5	5.0	5.5
Nov 21-22	5.0	4.5	5.4	5.2	5.2	4.5
1990						
Jun 11	3.3	3.3	--	3.0	--	--
Jul 9	3.3	2.2	--	5.8	--	--
Sep 17	--	4.5	--	7.5	--	--
Oct 15	7.0	5.1	--	6.3	--	--
Nov 19	7.8	5.4	--	6.0	--	--

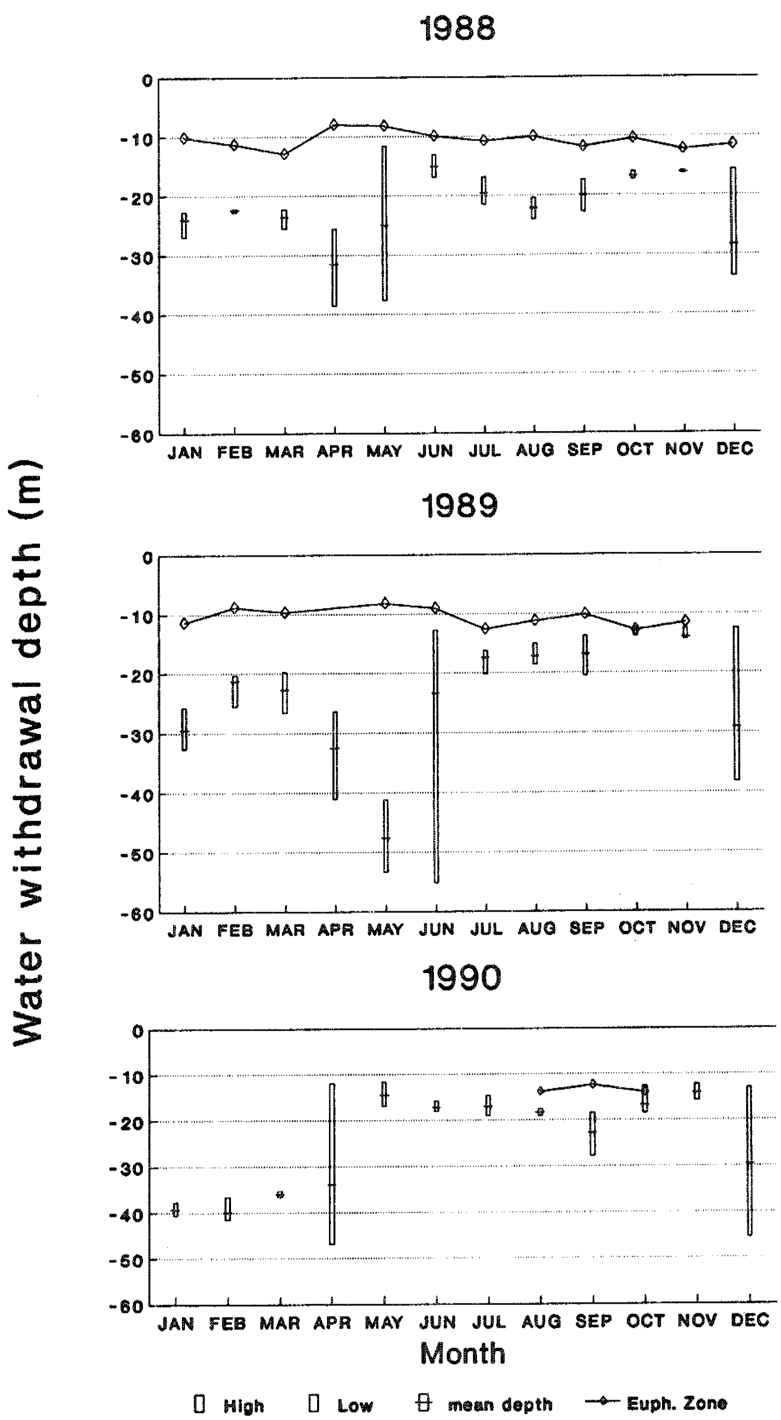
Appendix J. Chlorophyll A (ug/L) in Dworshak Reservoir, Idaho.

	River kilometer five	River kilometer 56	Elk Creek
1990			
Feb 26	<0.05	--	--
Mar 26	1.30	0.80	0.50
Apr 16	1.80	<0.50	1.90
May 21	2.10	2.20	1.80
Jun 11	2.60	1.90	2.20
Jul 9	1.28	0.48	1.60
Aug 13	1.00	0.80	1.40
Sep 17	1.60	<1.00	2.10
Oct 15	1.30	1.70	1.60
Nov 19	2.20	3.80	1.10

Appendix K. Nitrogen at river kilometer five in Dworshak Reservoir, Idaho.

	Total nitrate as N (mg/L)	Total NO_2+NO_3 as N (mg/L)	Total Kieldahl nitrogen as N (mg/L)	Total ammonia as N (mg/L)
1987				
Nov 16	0.071	--	--	--
Dec 14	0.016	--	--	--
1988				
Jan 14	<0.001	--	--	--
Feb 18	0.080	--	--	--
Mar 18	0.084	--	--	--
Apr 14	0.007	--	--	--
May 13	<0.001	--	--	--
Jun 20	0.004	--	--	--
Jul 20	0.010	--	--	--
Aug 17	0.036	--	--	--
Sep 14	0.008	--	--	--
Oct 13	0.021	--	--	--
Nov 18	0.013	--	--	--
Dec 16	0.034	--	--	--
1989				
Jan 17	0.063	--	--	--
Feb 14	0.135	--	--	--
Mar 16	0.089	--	--	--
Apr 19	--	0.067	0.190	0.097
May 10	0.010	--	0.090	0.036
Jun 16	--	0.003	0.120	0.012
Jul 21	0.004	0.004	0.260	0.013
Aug 21	--	0.008	0.130	0.049
Sep 21	--	0.001	0.140	0.025
Nov 27	--	<0.001	0.050	<0.001

Appendix L. Water withdrawal depth and euphotic zone depth for Dworshak Reservoir, Idaho, 1988 - 1990.



January 6, 1993

Mr. Robert Austin
Division of Fish and Wildlife, PJSR
Bonneville Power Administration
P.O. Box 3621
Portland, OR 97208-3621

RE: DE-A179-87BP35165 (Project 87-407) Dworshak Reservoir Investigations; DE-A179-87BP35167 (Project 87-99) Dworshak Dam Impact Assessment

Dear Mr. Austin:

We are pleased to provide the enclosed combined final completion report for the reference projects. This document has been jointly prepared by the Nez Perce Tribe Department of Fisheries Management and the Idaho Department of Fish and Game pursuant to reporting requirements of our respective intergovernmental agreements.

Thank you for your assistance in implementing these tasks.

Sincerely,

Samuel N. Penney, Chairman
Nez Perce Tribal Executive Council

Jerry M. Conley, Director
Idaho Department of Fish and Game

Merle V. Powaukee, Manager
Department of Fisheries

Steven M. Huffaker, Chief
Bureau of Fisheries

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